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POWER

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Preventable Waste Is Unsocial

INDUSTRIAL accidents are losing skirmishes in the battle of man with his environment.

And, as a whole army and cause is affected by defeat, even in a small engagement, the consequences of an industrial disaster are of more than local significance and involve many others than those directly injured.

The cost of the occurrence becomes a charge upon the business that must be borne by every user of its product.

Insurance simply spreads the cost to every purchaser of indemnity, the price of which depends upon the aggregate rate of loss.

If this is true of the momentary and spectacular effects of a fire, a boiler explosion, or a flywheel or turbine failure, why is it not equally true of the continuous and unsuspected wastes that may be going on in the power and other departments of industrial establishments?

Every ton of coal unnecessarily burned adds to the depletion of the fuel resources of the world; requires the services of everybody concerned in its winning, marketing and transportation; cumbers traffic; and requires labor and machinery to handle and fire.

And if the selling price of the product is based upon its cost, the consumer pays the bill.

More and more it is coming to be recognized that industry is based upon service; that the producer is under obligation to his customers; that all essential commodities are, in a sense, charged with public interest; and that those who have undertaken their production owe it to the public that they shall be produced as economically as possible.

The continual endurance of an industrial waste is a matter for concern beyond its immediate effect upon the fortune of the perpetrator.

The importance of such wastes upon the potency and economics of the nation was brought out forcibly under the stress of war, and means were taken to reduce them.

Are they not equally important to our prosperity and well-being in times of peace?

And is not a voluntary recognition of their responsibility and obligations in the matter by those who are practicing or permitting such wastes the best way to arrive at their reduction and avoidance?

POWER *Stands for . . .*

1. Making Power When It Should Be Made
2. Buying Power When It Should Be Bought
3. Cheaper Power Through Modern Equipment
4. Easier Financing of Equipment Purchases
5. Better Use of Byproduct Heat and Power
6. Operating Methods That Save Money
7. Less Waste in Transmission and Application

Better Use of Byproduct Heat

MUST the industrial plant spend good dollars for heating of river water? That is what happens when the heat rejected in the condenser is discharged with the cooling water to the sewer. In the present state of the art there seems to be no alternative for the central station, except when this cooling water can be used by an adjacent industrial plant, as is done at Sand Springs, Oklahoma.

But the average industrial plant can generally profit by dispensing with the condenser entirely and exhausting steam from the turbines or engines directly into the process mains, as is pointed out by E. H. Barry, in his article published elsewhere in this issue. When the power load does not balance with the heating load, advantage can be taken of accumulators, reducing valves and other devices, to achieve the most economical possible layout.

The point of the matter is that the industrial plant must be interested in obtaining as nearly complete utilization as possible of the heat content of the fuel burned. If this can only be obtained by a sacrifice of efficiency in electrical generation, it still pays; for total costs, not electrical generation costs, are what count. When this is widely realized and acted upon, the savings obtained will pay for the necessary plant changes many times over.

Making Research Count

EVERY year sees greater expenditure of human effort and money for research, both scientific and applied. Purely scientific research brings incalculable benefits to all; but what the power engineer is most directly interested in and where he can help the most is in the applied research carried out by the manufacturers who supply the equipment he uses.

These firms do an immense amount of work in improving the equipment they make and often in developing entirely new types. The main urge for them to do this is competition. In order to keep their places in the market, they must make these advances.

But, too often, changes made in this way are not as suitable to the needs of the power plant as might be. This is not the fault of the manufacturer, but rather of the power engineer. For if he would keep the equipment makers thoroughly informed as to how their products perform in service and as to what new devices or improvements are needed, the results of the manufacturer's research would be much more satisfactory. Here is an opportunity for the engineer to help improve things without much effort on his part.

A Bigger Scrap Pile Would Pay Dividends

A HANDBOOK issued recently by an English firm contains a table showing the average life of various types of machinery. In view of the rapidity with which American factories scrap machines, a lathe lasting not much over five years, it is surprising that the English assume twenty years of useful life for similar tools.

Is not the radical difference in the attitude of the two nations on machinery obsolescence one reason for the unhealthy condition of some English industrials? Hesitancy to discard inefficient machines, as long as they are in good mechanical condition, prevents the reduction of manufacturing costs. Meeting competition that has availed itself of the latest labor-saving devices then becomes difficult.

The same handbook sets the life of English power-plant machinery at twenty years, and it must be confessed that in America about the same life is assumed. It is not a common thing to find a factory power plant where boilers in good condition have been replaced by newer models of a more efficient type. Taken as a whole, power plants, with the exception of the central stations, have been content to get the best out of the existing machinery.

If England's habit of keeping old machine tools at work is responsible for its present industrial stagnation, may not the unsatisfactory position of the factory power plant in this country be likewise due to its fondness for old boilers and engines? If a broad policy of power-plant rehabilitation were adopted, would there not be fewer plants closed down, and would not the power savings be reflected in a marked reduction in the cost of the finished products?

Those Who Criticize Should Know the Facts

RECENT controversy between the electric utility company and the owners and operators of large buildings in New York City concerns the right of the latter to buy current wholesale and retail it to tenants at a profit. The utility desires to stop this practice, claiming that it reduces its income. The real estate interests fight hard to hold the privilege, which they say helps to rent their buildings; and threaten, if the resale right is withdrawn, to build their own power plants.

Anent this possibility the president of the New York

Real Estate Board stated that the creation of individual power plants would increase the smoke nuisance and aggravate the traffic situation because of the transportation of coal and ashes.

Many peculiar reasons have been advanced for not installing power plants in large buildings. Among these, the statements quoted are not, perhaps, the most naïve, but they stand well to the fore.. To say that the private plant, of the size used by the office buildings and hotels referred to, need make more smoke than the central station, is a mistake. To say that the coal and ash transportation problem will be any worse than is now the case, disregards the fact that the thousands of heating boilers now operated in these buildings use nearly as much coal as would be needed if electric power were also made.

When people talk against the private power plant, whatever their motives, they would be well advised to base their arguments on knowledge of the facts.

Burning Fuel Oil in Gasoline Engines

NEWSPAPER publicity given a statement of a Philadelphia Rapid Transit official will doubtless lead many to believe that heavy oil is to be the future fuel of the automotive engine. Facts hardly justify such hopes, nor does history bear out the claim that the principle of the fuel-oil vaporizer mentioned is new.

Years ago, before the advent of the high-compression heavy-oil engine, the oil producers were dependent upon gas and gasoline engines for well-pumping purposes. In the Eastern fields the wells supplied ample gas for the engines, but in the California fields the asphaltic oils carried too little gas to meet the requirements.

The alternative was the gasoline engine. But the folly of hauling back its light oil fuel from the refinery to the field prompted many engine builders to evolve ways of using crude oil in the engines.

The behavior of gasoline and fuel oil under usual atmospheric temperature conditions is quite different. The vapor pressure of gasoline is such that an explosive mixture can be maintained even down to freezing temperature. On the other hand, the vapor pressure of fuel oil is so small, even at summer temperature, that the amount of fuel-oil vapor in a volume of air and vapor is not explosive. A high-grade distillate, such as kerosene, must be heated before it will give off enough vapor to produce an explosive mixture.

With fuel-oil, devoid as it is of light constituents, heating by the hot cylinder is not enough. Early experimenters boldly decided to attach a retort to the engine and feed into the air stream only the resulting oil vapor. This would avoid the carburetion difficulty and insure a burnable mixture of air and fuel vapor. A source of heat for the retort was needed, and that an automatic one. It is not surprising, then, that the early engine designers seized upon the hot exhaust pipe as the solution. Its temperature varied directly with the load, which met the requirement that the retort must vaporize more oil at the heavy engine loads. As finally worked out, there was added to the exhaust line a pot containing a compartment holding a series of baffles down which the oil trickled. The heat absorbed from the exhaust gases was ample to distill the fuel needed.

It was found, however, that unexpected operating difficulties arose. The fuel was heavy California crude and a tar-like residue insisted on settling in the retort. Equally objectionable was the fact that at low loads the exhaust gases were too cold to gasify the oil properly. The engine was essentially a full-load unit. The development of the hot-bulb oil engine eliminated the distilling engine, although even now an occasional one is found.

The transit company's claim of increased horsepower per gallon of fuel is open to question, but one must remember that when a man is sold on an idea, he will obtain success by a more rational operating procedure. Even colored water sprinkled on coal has been known to increase a boiler's efficiency.

Common Sense Wins

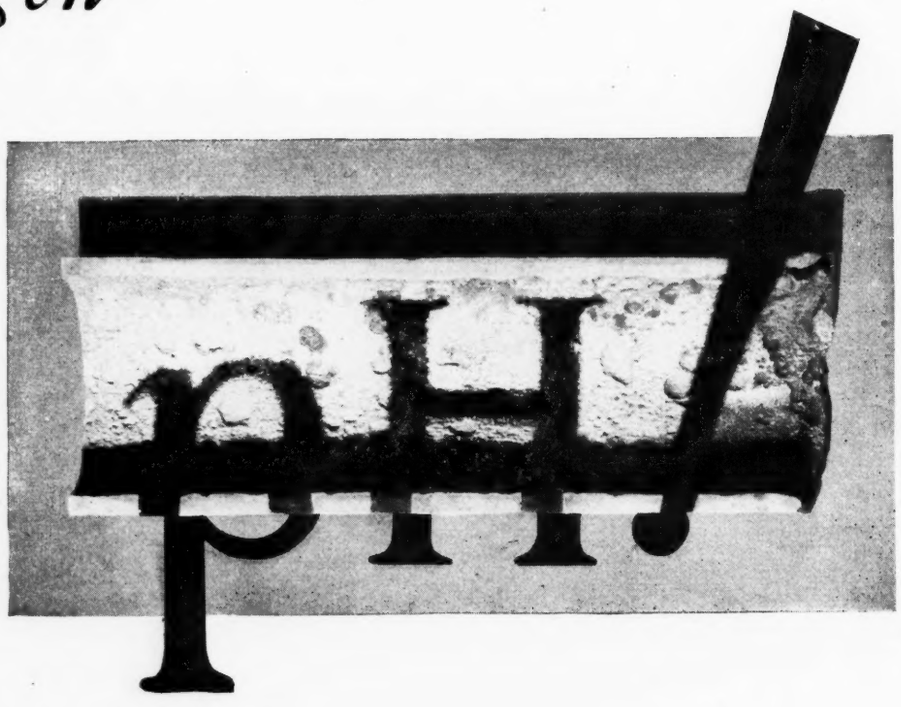
CHICAGO, by a recent decision of the United States Supreme Court, lost its long fight for increased water diversion from Lake Michigan. This decree means that eventually 4,333 second-feet now diverted from Lake Michigan in excess of that to which Chicago is entitled, will flow in its natural course. Power development and navigation on the Great Lakes, the Niagara and the St. Lawrence Rivers will be greatly benefited.

In the Niagara and St. Lawrence Rivers the excess water now being diverted by Chicago from Lake Michigan would produce about one-quarter million horsepower. This power, at twenty dollars per horsepower-year, is worth five million dollars. To this must be added the large increase in cost to navigation.

Taking this natural resource from Canada and New York State, as Chicago has done, is the same as some outside interest taking from Illinois natural resources of an equal value and placing an increased cost on her transportation facilities. Such a thing would not be tolerated by Chicago and the rest of the State of Illinois. Yet, year after year Chicago has insisted upon imposing this burden on the states bordering the Great Lakes, to handle sewage that should have been taken care of by other means. The decision of the court is a triumph for law, order and common sense.

THE article "Combining Heat and Power in a Southern University," appearing in the January 8 number, described an interesting purchase agreement whereby a uniflow engine was secured by a *one dollar* down payment. The remaining amount of the purchase price is being paid by installments determined by the savings resulting from the unit's operation. The article should have stated that this is a standard form of purchase agreement made by the Skinner Engine Company, who were the builders of the uniflow engine described.

Hydrogen Ions are the pH Key to Corrosion



By A. A. Markson and Paul Fritz
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THE control of corrosion is now a major problem with most power plants. As to what causes it, even the doctors disagree, which has led to confusion among the engineers. It is due to the latter to have clarified and explained to them some of the fundamental ideas underlying present-day practice in the prevention of corrosion.

Let us say that a chemist and a power-plant man are discussing ways and means of combating corrosion. There comes a point in the animated and, so far, even discussion at which the chemist suddenly rings in his trump card and with a triumphant voice says, "*p*H." At this point the power-plant man breaks in to find out what *p*H means, listens to a few bewildering explanations and the conference is off.

Now, the chemist himself may not know much more about *p*H than his engineer friend, but he is playing on his home grounds and has it all his own way. Nevertheless, *p*H is something that should not be a mystery to the intelligent engineer. It represents a concept which is assuming more and more importance in the everlasting war against the corrosion of iron and steel.

In addition to satisfying the praiseworthy ambition of checkmating the plant chemist, there are strong reasons for acquiring a working knowledge of *p*H. To know the *p*H of the raw water the plant is using, is to know a great deal about its corrosive properties. Information obtained in this manner is a great deal cheaper than the story gleaned from corroded feed lines, boilers and economizers.

In addition, there are some plants treating their feed water with soda ash or caustic soda. In many of these it is the custom to add so many pails of soda daily without particular care as to its addition as long as it gets in the boilers. A very simple test of the feed water—so simple in fact that one need not know what *p*H means to perform it—will enable the engineer to check the addition of chemical, see whether he is adding too little or too much, and avoid the danger of priming, which may occur if the chemical hits the boiler in slugs.

No one would knowingly feed boilers with acid water. Nevertheless, it is being done in more plants than one might suspect. When mine waters are used in boilers, operators are usually on guard because they know these waters are acid. But who would think that ordinary potable waters may be highly corrosive? Ordinarily, upon viewing evidence of corrosion by these waters, no time is lost in blaming the dissolved oxygen for the condition. This is partly right; the complete solution, however, is bound up with *p*H. Economically, it would be difficult to think of any power-plant information capable of paying as great dividends to the intelligent engineer.

To denote the potential strength of an acid or alkaline

solution with respect to the acid or basic properties thereof, the *p*H value is used. It is the term for a scale of acidity and alkalinity, just as Fahrenheit is the name of a temperature scale; *p*H7 is as significant on that scale as is 100 deg. F. on the temperature scale.

The simplest definition of an acid imaginable is this: An acid solution is a liquid with a sour taste. Likewise the simplest definition of an alkaline solution is that it is a liquid with a bitter taste and a soapy feeling. It is well known that any acid and any alkali, when mixed in the proper proportions, produce a resultant solution which is neither sour nor soapy, but rather salty to the taste. This is true, no matter what acid or alkaline combination be used, as long as the proper quantities are mixed.

Neutralizing an Acid

There probably is a common substance in all acids which makes them sour, and there is a substance common to all alkalis which makes them bitter and soapy. When mixed in certain proportions, these substances apparently destroy each other, because the resultant solution tastes neither sour nor bitter nor soapy.

"But," interjects the reader, "could not these two substances have combined so as to produce the resultant salty taste?"

The answer to that is that no matter what different kinds of acid and alkaline solutions we experiment with, we always end by obtaining a salty solution; so that it is reasonable to assume that the sour ingredient and the soapy ingredient have *neutralized* each other and that remaining parts of the substances have determined the salty property.

We can then picture the process like this: An acid has two parts; one part gives it the sour, acid property and the other, which we shall denote as the "acid substance remainder," is the rest of it. Acids are, therefore,

Fig. 1—Testing for pH is shown in its simplest form The operator is comparing the color developed by a special dye in a sample of feed water with a printed color chart.

different in kind only because the acid remainders are different. Likewise an alkali can be considered as being composed of a soapy part and an alkali remainder. We mix the two. Acid (sour part plus remainder) and alkali (soapy part plus remainder) produce a tasteless substance and a salt, the taste of which depends on the *kinds* of alkalis and acids we have used.

Naturally, the next inquiry would be as to the nature of the tasteless substance that now must obviously contain both the acid and the alkaline principle in exactly equivalent proportions. It is water. Thus we can state that any acid and any alkali, when mixed, will produce

Fig. 2—Section of feed-water pipe etched with ammonium citrate, showing corrosion due in great part to low pH

water and a salt, the character of which will depend on the kind of acid and alkali.

That is an explanation of neutralization our chemist friend will have a hard time improving.

The water contains both the acid and alkaline ingredient. As everyone knows, water is composed of two units of hydrogen and one of oxygen, usually written as H_2O. For our purpose we shall write it H-OH, which is the same thing.

Combinations That Are Acid

The acid, or basic, principle must therefore be two or four possible combinations, forming water, which are OH, H_2, O, H. We must thank our much misunderstood chemist friends for finding out that H was the acid principle and OH was the alkaline principle. All acids contain hydrogen, H, and all bases contain a combination of hydrogen and oxygen, OH, which we call hydroxyl.

"Well," asks someone, "can't a substance be an acid or an alkali without having hydrogen or hydroxyl? How about sodium carbonate, soda ash, which has the formula Na_2CO_3. Do you mean to say that that is no alkali?"

When sodium carbonate (soda ash) is dissolved in water, the solution is strongly alkaline. What takes place is that the sodium carbonate ionizes into sodium ions and carbonate ions. Some of the sodium ions pair off with hydroxyl ions of the water, forming the very alkaline sodium hydroxide, while the carbonate ions pair off with the hydrogen ions of the water, forming the weakly ionized carbonic acid ion. The result is that the solution acts strongly alkaline. This process is spoken of as hydrolysis. Trisodium phosphate acts in the same

manner, the sodium pairing with the hydroxyl and the phosphate with the hydrogen.

In general any salt that is formed by the union of a strong base and a very weak acid will react noticeably in that manner. Soap, which is the compound formed when a strong alkali like soda ash or caustic soda neutralizes a weak acid like palmitic, is an excellent example of the last statement.

Not all substances that contain hydrogen are acids. Obviously, hydrogen by itself is not an acid. Let us take hydrochloric acid for example. Hydrogen chloride is a gas which, when dissolved in water, gives us hydrochloric acid, both gas and acid having the formula HCl. When the gas is dissolved in water, the water loosens up the molecule so that it breaks in two. This action of

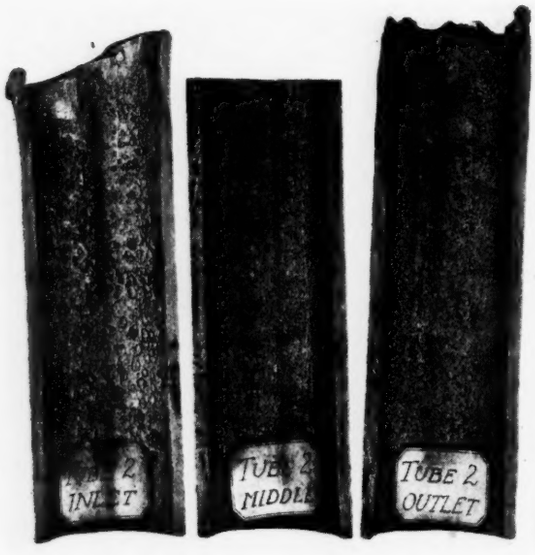

Fig. 3—Sections of steel economizer tube, showing corrosion due to oxygen, greatly aided by low pH

water, as well as of some other solvents, that breaks up certain substances, is called "hydrolysis," and substances that are so affected are known as "electrolytes." When a molecule of HCl has broken in two, the H acquires, conventionally, a positive charge of electricity and the Cl a negative. We call these charged particles "ions," which is from the Greek, meaning wanderers. We write them as H and Cl and refer to them as "hydrogen ions" and "chlorine ions." Likewise, we dissolve some caustic soda, otherwise known as sodium hydroxide, or NaOH, and we find that we have in solution Na^+ and OH^-, or sodium ion and hydroxyl ion.

Some Ions Are Missing

If we determine the quantity of ions produced, we find that it is less than that which we originally dissolved in the water in the form of dry substance. Let us say that all the substance is split up the instant it dissolves. The ions start moving around and collide with each other. Every time a positive ion hits a negative one, the original substance is formed and immediately broken up again. What we mean when we say that a solution has a certain hydrogen- or hydroxyl-ion concentration is not that some ions have split off and remained that way, leaving the rest of the material intact, but that if we could make a survey of the substance at any single instant there would be a definite amount of the substance in the ionic form.

One acid solution may be said to be stronger than another if it has more hydrogen ions per gallon. Likewise, one alkaline solution may be said to have more acidity than another if it has more hydroxyl ions per gallon. Conversely, we can state that the stronger alkaline solution is the one having less hydrogen ion concentration.

We have succeeded in developing a real basis for the rating of acids and alkalis. A few common substances may be rated in order of decreasing ability to form solutions having hydrogen ions:

Hydrochloric acid.	Aluminum hydroxide.
Sulphuric acid.	Iron hydroxide.
Acetic acid.	Ammonium hydroxide.
Citric acid.	Sodium hydroxide.
Palmitic acid.	Potassium hydroxide.

We see a more or less gradual transition from the acid scale to the basic. About the middle of the scale we have a substance, aluminum hydroxide, which can react in both an acid and a basic manner, depending on its hydrogen-ion environment. The neutral point would come a little below palmitic acid, the acid found in palm oil. Of course, pure water occupies the neutral point, for it possesses hydrogen and hydroxyl ions in exactly equivalent amounts. This brings us to the most important concept we have yet attempted to develop.

Hydrogen Ions in Water

Water itself ionizes slightly, so that a solution of pure distilled water contains a small number of free hydrogen and hydroxyl ions. We speak of pure water as being neutral because the hydrogen ions present are always equal to the hydroxyl ions. Chemists may write it $H - OH = H^+ + OH^-$.

One hydroxyl ion weighs seventeen times as much as a hydrogen ion, so that the literature speaks of one gram ion as a unit quantity.

One gram ion of hydrogen refers to one gram of hydrogen ions. One gram ion of hydroxyl refers to seventeen grams of hydroxyl ions.

In water at room temperature there is present about one ten-millionth of a gram ion of each per liter, so that the total ionic content amounts to one five-millionth of a gram ion, by simple addition.

There is a law of fundamental importance known as the law of mass action. As applied to water and water solutions, it can be stated very simply. The concentration of hydrogen ion multiplied by the concentration of hydroxyl ion (expressed in gram ions) is a constant quantity, for any given temperature. That is $OH^- \times H^+ = K$, regardless of what other substances may be present; K is spoken of as the *ionization constant of water*. At room temperature we have stated that there exists one ten-millionth of a gram ion of hydrogen and the same of hydroxyl. As one ten millionth equals 10^{-7},

$$OH^- \times H^+ = 10^{-7} \times 10^{-7} = 10^{-14} = K.$$

The exponent of the hydrogen ion concentration is -7. This exponent, with its sign changed, is the *pH* of the solution. Pure distilled water is therefore said to have a *pH* of 7. The limits of the *pH* scale are 0 and 14, obviously no more attainable in practice than is absolute zero on the temperature scale.

Mathematically, the *pH* of a solution is equal to the logarithm of the reciprocal of the hydrogen ion concen-

tration, which is merely another way of stating it. Solutions of high *pH* are low in acidity and vice versa.

Finally, let us try a simple computation of *pH*. We are told that if we keep our feed water at a *pH* of 10, we will effect a great improvement in our feed line and economizer corrosion conditions. How much caustic soda will we have to add to the water to get this *pH*?

We write, $OH^{-7} \times H^{-7} = 10^{-14}$, and, for our conditions H must equal 10^{-10} gram ions per liter.

Neutralizing with Caustic Soda

Substituting, $OH \times 10^{-10} = 10^{-14}$, and solving for OH, we see it equals 10^{-4} gram ions of OH per liter. Remembering that one gram ion of OH is equal to seventeen grams, we need to supply 17×10^{-4} grams of hydroxyl per liter, or 1.7 thousandths of a gram per liter. But a thousandth of a gram, or one milligram, per liter is equal to one pound per million. Therefore, we need 1.7 lb. of hydroxyl per million pounds of water. This is supplied by adding four pounds per million of pure caustic soda. Any correction for the amount of hydroxyl ions originally present in pure water is, in this case, seen to be negligible.

Let us say we test our feed water, which has been treated with four pounds of caustic soda per million pounds of water. The *pH* in all probability does not come out 10. The reason for this is that our raw water is impure and usually possesses some acidity or alkalinity to start with. Of course, if our chemical and water are pure, our calculation will be satisfactory. In practice we usually adjust a sample of the raw water and measure the amount of alkali necessary to bring it to the correct *pH*. Testing for *pH* is extremely simple, much easier in fact than the procedure of titration so generally followed in boiler plants as a check on alkalinity.

The Boiler Unit of Evaporation Should Be Named

By William Jay Dana
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IN *Mechanical Engineering* for September, 1928, W. A. Shoudy and W. H. Jacobi presented "A Suggestion for Rating Steam Boilers." This paper gives several constructive suggestions of considerable interest. There has been quite a lot of discussion among engineers for several years about the B.t.u., the boiler unit of evaporation, the therm and so on. Much of this discussion has been jocular or only semi-serious, as when it was suggested that the American B.t.u. be made equal to 1,000 ft.-lb. of work, in order that it be bigger than the British. Similar equally ridiculous ideas have been advanced.

The author has suggested, also in a half humorous way, that the boiler unit of evaporation be termed the "Bute" (see *Power*, June 26, 1928, page 1154). This is made up from the initial letters of the phrase to which it applies and is pronounced as one syllable. The plural should be "Butes," also pronounced as one syllable.

It was my intention that the "Bute" should equal 1,000,000 B.t.u. This would have many advantages. It would give the large unit that we need. It would be different from the English therm. And it would replace the awkward term "one million B.t.u.," that must now be used so frequently.

Since the term "boiler horsepower" (now being eliminated from the engineering vocabulary) is equivalent to 33,479 B.t.u., the "Bute" would be equal to about 30 times as much. This would be a convenient figure to remember for those who felt they should have a mental relation between the old and new units.

The average large steam generator with superheater and feed-water heater requires from 1,000 to 1,100 B.t.u. per lb. of steam evaporated. If 10,000 lb. of steam were delivered per hour, about 10 "Butes" would be required. For 500,000 lb. of steam per hour, 500 "Butes" would be needed. This represents the limit of present capacity, but if generators capable of producing 1,000,000 lb. of steam per hour are developed, 1,000 "Butes" is not an unwieldy term to use.

The term "per million B.t.u." has been used for stating the duty of pumps for so long that it seems easier to say "duty per Bute" than "duty per thousand kilotherms."

The term "Bute," if it stands for 1,000,000 B.t.u., is easily used throughout technical literature. In Philip Carey Company's Bulletin 101-A, page 3, appears "at a cost of $0.30 per million B.t.u., which is a conservative figure, the annual loss from one square foot of 12-in. bare pipe (750 — 80 deg. F.) is $36.27." It would be much simpler to say $0.30 per Bute.

In *Power*, July 24, 1928, page 139, W. D. Canan uses 1,000,000 B.t.u. in the curves in his article on "What It Costs to Generate Industrial Power." In *Power*, July 26, 1927, page 140, in the article, "What Capital Expenditure is Justified by Thermal Savings?" the comparison of fuel costs per million B.t.u. is made. In both cases the use of the term "Bute" would be simpler.

These are a few examples noted recently. Their number could be increased indefinitely. The term "Bute" is suggested, as it is simple, easy to remember, and easily associated with the B.t.u. But whether it or the suggested "Runford" or some other term is finally adopted, it is really necessary that the term should stand for 1,000,000 B.t.u.

Make or Buy?

Is it better and cheaper to make your own power or buy it? While no general answer can be given, it is interesting to note how frequently of late a combination of purchased and locally generated power has been found best. That is the case with the new Chicago plant of the Campbell Soup Company, to be described in the February 12 issue, where by product power from a 1,000-kw. turbine generator is supplemented by purchased current.

CONDENSERS *In Industrial Plants* May Waste Heat

By E. H. BARRY

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INDUSTRIES using large amounts of steam and power in their processes have opportunities for economy not available to the central station. Since the industrial plant has use for the heat of steam at both high and low pressures, the laws governing the efficient utilization of heat differ from those effective in central stations. The central plant is manufacturing only one commodity, electricity. The industrial plant requires electricity to operate its machinery, provide illumination and perhaps for electrochemical processes; but in addition to these requirements it needs steam to supply pressure and heat for cooking, drying, heating or other processes. The criterion of central-station efficiency is the amount of heat rejected outside the confines of the prime movers.

$$\text{Efficiency} = \frac{\text{output}}{\text{input}}$$

$$\text{Output} = \text{input} - \text{waste}$$

$$\text{Thus efficiency} = \frac{\text{input} - \text{waste}}{\text{input}}$$

Efficiency is a maximum when waste is a minimum. This formula will apply to the operation of any machine, process, or plant as a whole. The waste associated with any machine or process is relative, since the waste in one case may have useful possibilities as input in another case. This obvious point is often overlooked in an investigation of plant efficiency or heat balance.

The function of the industrial power engineer is to maintain plant efficiency at a maximum. The central-station power engineer is interested in the efficiency of conversion of the latent heat of coal into power. In applying the foregoing formula, he regards as waste all the heat rejected by the prime movers. From his point of view a non-condensing turbine is an inefficient unit compared with one in which the steam is condensed at high vacuum. The industrial plant, however, may have use for low-pressure steam in process and, under certain conditions, could use all the steam exhausted by a non-condensing turbine. The industrial power engineer knows that under these conditions his plant is operating efficiently, since he has utilized all the available heat from the coal. Waste has been eliminated. If a condensing turbine were used, process steam would have to be obtained direct from the boilers through a reducing valve or extracted from the turbine, and heat would be lost in the condenser cooling water. This waste heat is the latent heat of vaporization of the steam at the pressure in the condenser and would amount to more than 1,000 B.t.u. for every pound of steam condensed.

The central-station engineer might argue that, since he was producing a kilowatt-hour with fewer pounds of steam with his condensing unit, the saving in steam would more than offset the heat wasted through the condenser. Such an argument deserves scant consideration, although frequently advanced. It overlooks the first law of thermodynamics, the conservation of energy. Under either condensing or non-condensing operation the process requires a certain amount of power and a definite amount of heat in low-pressure steam. Together, the power and heat represent a corresponding minimum amount of energy which must be obtained from the fuel burned under the boilers. In the case of the non-condensing unit the steam carries just sufficient energy to supply the requirements of the mill, whereas, when the condensing unit is used, sufficient steam must be taken from the boiler to provide enough energy to produce the mill needs for power and heat and, in addition, the heat wasted through the condenser; thus the non-condensing unit gives the best over-all efficiency.

This seems to the writer the common-sense way of looking at problems involving power and process heat. Textbooks on heat engineering stress the laws of thermodynamics. In these days when industrial plants are manufacturing their own

The Author Says

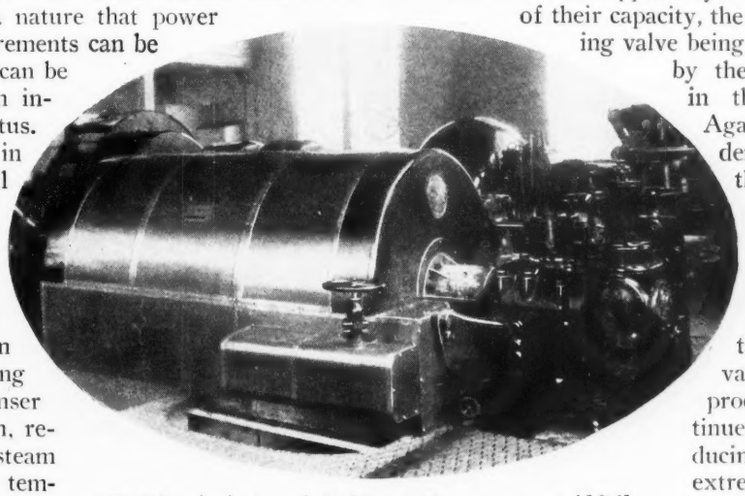
. . . Where industrial processes are of such a nature that power and process steam requirements can be balanced, the condenser can be branded as inefficient.

. . . Flexibility can be attained by other means without the losses attendant upon the use of a condenser.

power and either utilizing large quantities of steam in their own processes or selling steam to their neighbors, there is need for more intelligent thinking with regard to the conservation of heat. Thermodynamic laws do not apply to the plant taken as a whole. Thermodynamics is the study of the transformation of heat into work. The engineer must study the efficient utilization of heat, whether that heat be destined to be transformed into work in whole or only in part.

This point of view is difficult for the engineer trained in central-station practice. Our technical schools should point out the restricted application of thermodynamics in industry, and textbooks on heat engineering should provide illustrative examples of the use of process heat in conjunction with industrial power plants.

Too often, in designing a power plant for an industrial installation, emphasis is laid on the "efficient" operation of the power units. As already pointed out, it is possible that power-plant efficiency is obtained at the expense of over-all plant efficiency. In cases where industrial processes are of such a nature that power and process steam requirements can be balanced, the condenser can be definitely branded as an inefficient piece of apparatus. It can be justified only in those rare cases where all the heat in the cooling water can be utilized. The demands for hot water are seldom uniform, and where a high vacuum is maintained in the condenser, the cooling water leaves the condenser in a lukewarm condition, requiring reheating with steam to bring it up to proper temperature. When the demand for hot water ceases, the flow of cooling water cannot be stopped, but must waste its heat to the sewer. Process requirements for hot water can be supplied by low-pressure steam without the waste that accompanies the use of the condenser.



Turbine in industrial plant taking steam at 400 lb., extracting at 150 lb. and exhausting at 20 lb.

It may be said that the condenser is necessary to provide flexibility in the system, to take care of variations in the demand for power and low-pressure steam; but this flexibility can be attained by other means without the losses attendant upon the use of a condenser.

For example, suppose a boiler plant producing steam at 425 lb. gage, 146 deg. F. superheat. The heat content of this steam is 1,303 B.t.u. per lb. The normal demand for power is 5,000 kw. and the process requires 200,000 lb. per hour of 20-lb. steam. A non-condensing turbine is used, taking 400 lb. steam 150 deg. F. superheat at the throttle (there being a drop of 25 lb. through the superheater) and exhausting at 20 lb. gage direct to process. The turbine has a Rankine or cylinder efficiency of 60 per cent. The generator losses and losses due to radiation, friction, glands, etc., amount to 14½ per cent. Under such conditions a kilowatt-hour would be obtained with the expenditure of approximately 4,000 B.t.u.

With isentropic expansion from an initial condition of 400 lb. and 150 deg. F. superheat, a pound of 20-lb. steam would have a heat content of 1,092 B.t.u. Thus, each pound of steam theoretically releases 201 B.t.u. for conversion to work. With a cylinder efficiency of 60 per cent only 120.6 B.t.u. are actually available. The water rate of the turbine will thus be 4,000 ÷ 120.6, or 33.2 lb. of steam per kilowatt-hour. If the unit is generating 5,000 kw., it will take 166,000 lb. of high-pressure steam at the throttle and exhaust this quantity to the low-pressure line. The exhaust steam will have about 30 deg. F. of superheat, and to simplify the discussion, we will assume that the process requires this quality of steam.

Since the turbine exhaust is insufficient to supply the process demand, it will be necessary to take steam from the boilers through a reducing valve to make up the deficiency. A desuperheater will be required, since a direct expansion of the steam would give too much superheat in the low-pressure line.

Let us look at the flexibility of such a plant as this. Suppose the power demand remained constant and there is an increased demand for low-pressure steam. The additional steam is supplied by the boilers up to the limit of their capacity, the flow through the reducing valve being automatically regulated by the variation in pressure in the low-pressure line. Again, assuming the power demand constant, suppose the demand for process steam fell off. The pressure in the process line would tend to rise, thus cutting down on the flow of steam through the reducing valve. The demand for process steam could continue to fall off until the reducing valve closed. At this extreme the process line would be supplied with only the steam exhausted by the turbine, or 166,000 lb. per hour. Thus the system could automatically take care of a reduction of 34,000 lb. per hour below the average demand for process steam and could accommodate an increase in demand up to the limit of the capacity of the boilers.

Variations in the demand for power would be handled similarly, an increased power demand corresponding to a decreased demand for process steam and vice versa.

These variations in power and steam demand would be handled without the loss of heat, disregarding the boiler house for the moment. In the event that the demand for process steam falls to a point where the turbine exhausts more steam than is needed by the process, and if this condition were to continue over a considerable period of time, rather than permit 20 lb. steam to exhaust to the amosphere, it would be better to have a small condensing unit which could be thrown on the line until the power and process demands returned to normal.

The scheme outlined herein is described as a possible operating arrangement and illustrates a simple method of maintaining flexibility without the use of a condenser. It does not, however, represent the most economical solution.

Boilers can be operated at their best efficiency over long periods of time only if their load is maintained constant. A fluctuating load means that more difficulty

is encountered in maintaing constant CO_2. With each surge of steam from the boiler corresponding changes must occur in the feed-water regulator and in the rate at which fuel and air are supplied to the furnace, with corresponding fluctuations in the weights and temperatures of the stack gases. If the boilers can be operated at nearly constant rating, it is possible to obtain a maximum boiler efficiency.

Using Steam Accumulators

With a fairly constant flow of steam from the boilers variations in the demand for power and low-pressure steam can be handled by using a device for storing surplus steam, which surplus can be released to the low-pressure line when the demand swings in the opposite direction. Such a device is the steam accumulator.

Steam is admitted to the accumulator through a distributing pipe below the water level. The steam at first condenses until the temperature of the water is equal to that of the steam. Owing to the condensed steam, the water level rises and the pressure of the saturated vapor in the space above the water rises until it equals the pressure of the entering steam. The accumulator is then fully charged.

When the accumulator discharges, owing to a drop in pressure in the low-pressure process line, saturated steam leaves the accumulator and the internal pressure drops. The water in the accumulator flashes into steam until the internal pressure equals the pressure in the low-pressure line. The accumulator is then completely discharged.

In practice the accumulator would seldom be either completely charged or discharged. Steam will enter and leave the accumulator in accordance with fluctuations in the power and process steam demands. It is impractical to design accumulators for high pressure. When steam is generated at high pressure in the boilers, one or more turbines may be used which extract steam at a pressure suitable for the accumulator, the turbines being non-condensing and exhausting directly to the low-pressure line. Actual plant conditions will determine the proper combination of non-condensing and bleeder or extraction turbines.

The accumulator is essentially a reducing valve with large storage capacity, which reduces high-pressure steam to a lower pressure. If the process requires superheated low-pressure steam, the quality of the low-pressure process steam can be regulated by bleeding direct from the boilers to the low-pressure main through a reducing valve, the flow being automatically regulated by a thermostat control.

The substitution of accumulators for condensers and the use of high-pressure primary steam provide means for increasing the economy of industrial plant operation by conserving heat otherwise wasted in the condenser cooling water and by making possible the operation of the boiler plant at peak efficiency. Power becomes truly a byproduct, a kilowatt-hour being generated at the expense of only about 4,000 B.t.u. At this rate with coal at $4 per ton, having a heat content of 13,000 B.t.u. as fired, and with boiler efficiency of 80 per cent, power can be generated at a coal cost of 0.075c per kw.-hr. In other words, a kilowatt-hour can be generated with 0.375 lb. of coal.

The savings accomplished by eliminating the condenser can be easily computed for any given plant. There is first the recovery of all the latent heat of the steam condensed. The cost of a B.t.u. is known and the value of this wasted heat can readily be determined. Then there is the saving of the power to drive the condenser auxiliaries: The air, condensate, and circulating water pumps. The cost of the circulating water is a considerable item in some cases. There is upkeep on the condenser, the outage due to fouled and leaky tubes, the expense of tube cleaning and replacement.

Not the least of the evils accompanying a condenser is the possibility of raw water leakage into the condensate. This is a troublesome and expensive condition when boilers are operated at high pressures and ratings, as the chemical nature of the boiler feed water must be at all times under absolute control. Indeterminate contamination by raw water leakage through the condenser renders ineffiecient the most elaborate softening apparatus. Lastly, there is the saving of the investment in condensers and auxiliaries.

The total savings as outlined in this article would pay a handsome return on the investment required to make them effective. Furthermore, the substitution of an accumulator with no auxiliaries other than its automatic regulating valves in place of one or more condensers with their intricate network of tubes, and the array of auxiliary equipment necessary for their operation cannot fail to appeal to the plant executive whose objective is plant economy.

Beware of Dead Air When Entering a Boiler

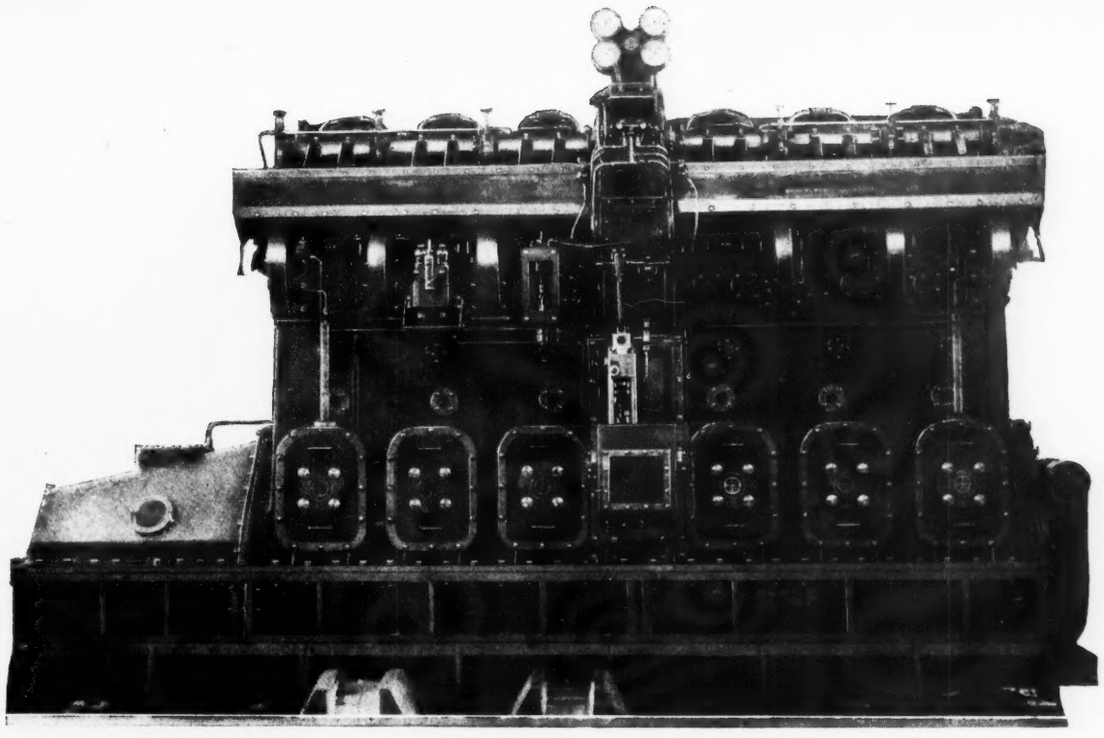
AN INSPECTOR of many years' experience recently had a narrow escape from death by suffocation when he was overcome by foul air in the drum of a boiler that had not been in use for three years, according to *The Locomotive*. Although he took the customary precautions to secure a circulation of fresh air, he made the mistake of entering the drum too soon. He had not gone far when a sensation of dizziness told him he was losing consciousness. Fortunately, he managed to crawl to the manhole and thrust his head outside before he collapsed. There he lay until the fresh air revived him.

When boilers are idle for a long time, the oxygen of the air inside seems to be used up in the formation of rust or absorbed by chemical reaction with some foreign substance left inside when the boiler was emptied. The result is stagnant, or "dead," air.

A boiler should never be entered until it has been ventilated thoroughly. In a coal-fired unit the condition of the air can be determined by thrusting a candle through the manhole. If the air is bad, the flame will burn feebly or go out. This test should not be applied where oil or gas is used as fuel, for the process of ventilating the boiler by drawing air through it may carry in explosive vapor, especially if there is a leak in the fuel line. The safe way in all cases is first to make sure the method of ventilation is such that it actually does cause circulation of air through the drum, and then allow ventilation to continue until there is no doubt that the stale air has been replaced by fresh.

Make sure the blowoff valve is closed when the boiler under inspection discharges into a blowoff line or tank to which other boilers are connected.

Notify the boiler-room attendants that you are about to make an inspection and warn them not to open a valve or do anything else to affect the boiler under inspection. If possible, have an engineer or other responsible man stand within speaking distance.



The Fuel Spray System

IS THE HEART

of the Solid-Injection Engine

While engineers are acquainted with the air-injection Diesel, not as many understand the proper way to maintain a solid-injection engine, although more of this type are built.

By H. F. Shepherd

THE McKechnie, or Vickers, system of fuel injection is distinguished from other systems by the use of cam-operated spray valves, all of which are in constant communication with a fuel manifold, or "rail" as the British call it. Fuel pressure is maintained practically constant within the manifold by the use of one or more accumulators which are often round steel flasks. The elasticity of the walls of the flask, together with that of the fuel, acts to prevent violent fluctuation of the pressure due to the fuel-pump deliveries and the spray discharges.

A pump having one to four cylinders charges the manifold and accumulators. The pump capacity is necessarily greater than the engine consumption, and the excess fuel is discharged back to the day tank through an adjustable pressure-relief valve.

The spray valve is the sensitive part of the system. Intimate knowledge of its construction, maintenance and adjustment is essential to successful operation.

The tip of the spray is perforated with from five to ten small holes through which the fuel is injected. These holes are inclined from 20 to 45 deg. downward from the horizontal, the amount of inclination depending mainly on the stroke-bore ratio or, in other words, upon the depth of the combustion space. In addition, the shape of the piston crown influences this angle.

Occasionally, an operator finds it wise to alter the size of the holes one or two thousandths of an inch. This is most common in marine practice, as quite often the hull, propeller and engine characteristics are not well related, and the engine cannot come up to speed. In this case the drilling should be reduced in size, since at lower revolutions the time duration of injection is increased and an excess of fuel is too easily admitted to engines under hand fuel control.

If stationary engines are operated at other than the designed speed, it may be well to alter the area of the drilling in proportion to the change in speed. If the

speed change is extreme, it is sometimes wiser to increase or decrease the number of holes in the same proportion.

The fuel viscosity has no marked influence on the discharge through the tip. If larger perforations are required for heavy fuel, it is usually because of increased consumption. For the ordinary range of fuels no change is required.

Wear of the perforations is slight unless a very sandy fuel is used. It is rarely noticeable if the fuel is centrifuged. Wear or destruction of the valve seat in the tip is the usual reason for replacing tips.

For cleaning the tip perforations, watchmaker's pivot reamers are used. The reamer is held in a pin chuck. Some operators prefer needles used in the same way, fearing that the drilling will be too much enlarged by the reamer. I have always preferred to finish new tips, at least, by very slight reaming. The slight outward taper and the elimination of burrs tend toward better results. Tips with drilling larger than 0.012 in. diameter are not often plugged in service, particularly after the tubing scale and small metal particles, almost unavoidable in new engines, have worked out.

A conical-pointed spray needle, such as shown in Fig. 1, is seated in the tip *a* in a variety of ways. Some operators prefer the lead hammer applied to the outer end of the needle *b*. This may be justified in an emergency, although it frequently results in breaking the end of the tip. It is certainly not a cure for leakage due to particles of hard material between the seat surfaces, although to defer a shutdown the hammer may be justified.

A punch, fitting the spray tip and shaped like its seat at the end, is a common tool for hammer forming the seat before assembly. If the tip is made of very ductile material for the sake of easy drilling, this is not bad practice. It compresses the metal or "cold works" it so that it withstands the hammering of the needle with less after deformation. The punch should be turned slightly between light hammer blows.

However the needle is seated, it should, if pointed, be ground in slightly with fine automobile valve grinding compound. This should be done with the needle and tip assembled in the body. If the needle cannot be turned, the tip may be turned, the needle being slightly raised and lowered at intervals and the seat rotated progressively only part of a turn at a time and reversed in the approved fashion. A very little grinding must suffice or the needle will be shouldered and ruined when put into service.

The flat seat used on the valve shown in Fig. 2 is

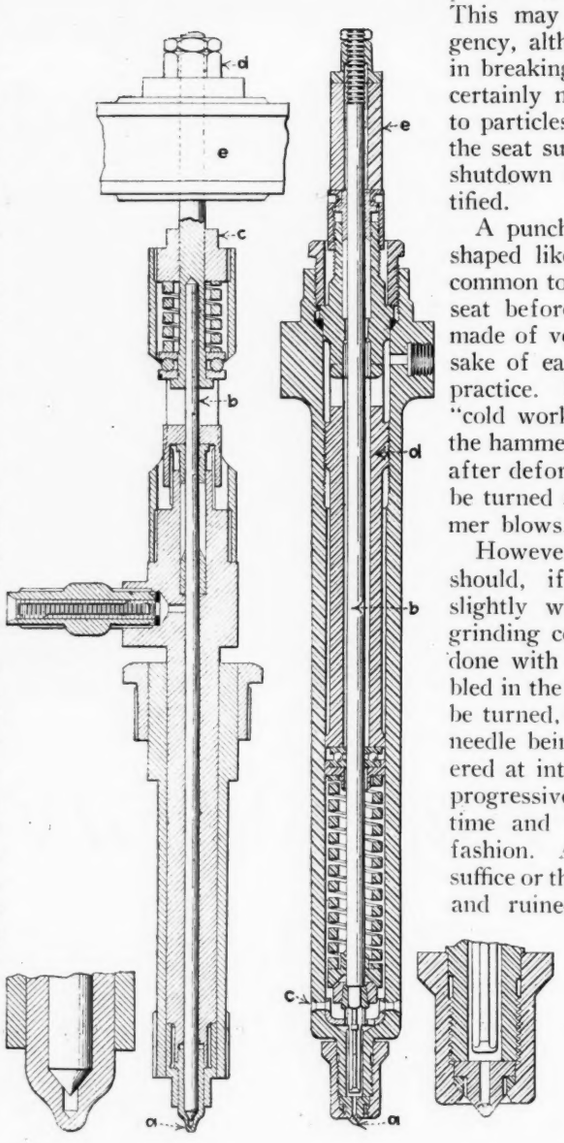
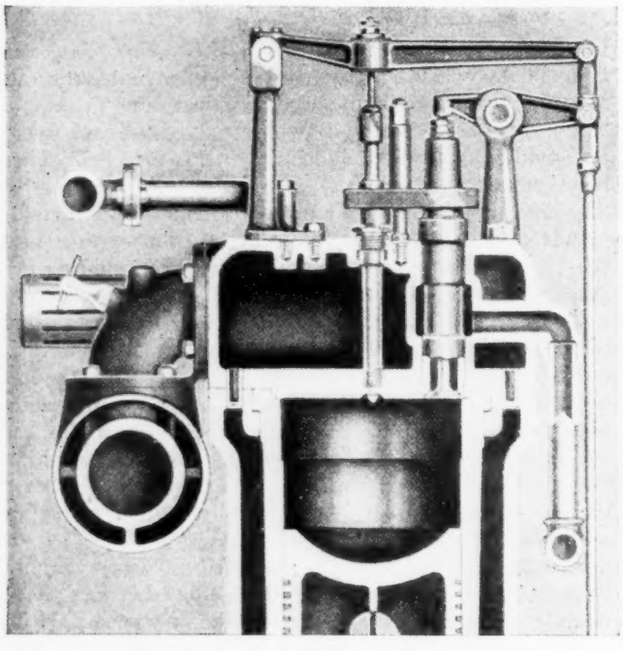


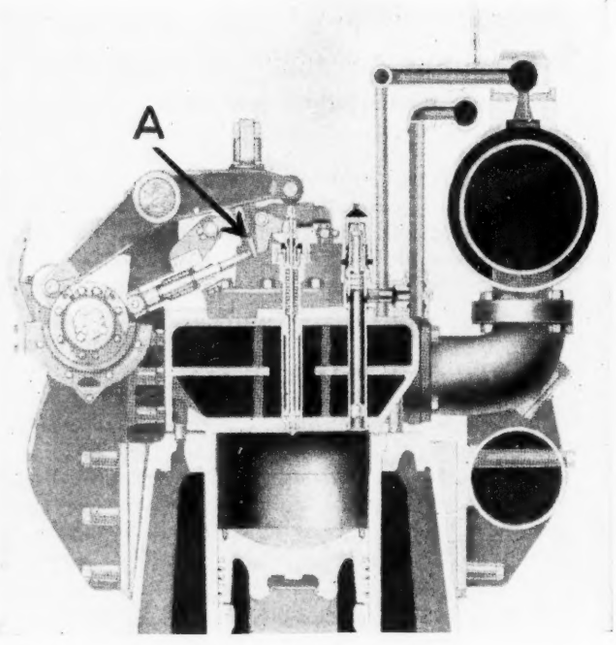
Fig. 1—A typical spray valve with a conical seat

Fig. 2—This needle valve has a flat seat

Fig. 3—Spray-valve gearing using push rods

Fig. 4—Needle valve lifted by direct action





finished by the time-honored practice of lapping. The needle is lapped by catching the upper end in a good lathe collet. Some cylindrical part near the seat end is centered in a steadyrest. The lap is a little disk of cold-rolled steel driven by a toolpost center grinder, the disk taking the place of the emery wheel. The rotating disk is charged with abrasive by applying to it a piece of harder steel coated with oil and "fff" emery. The emery embeds itself in the disk, which is then rotated against the end of the slowly revolving needle with light pressure. A mirrorlike and accurate finish is produced. The needle point is usually made harder than the seat in the tip, so it is rarely indented or abraded in use. If it is so damaged, it should be ground with a fine cup wheel before lapping.

Finishing the Tip

The tip is finished on a grooved cast-iron lapping plate with the same abrasive. The operation consists of merely inverting the tip on the charged plate and giving it a few careful passes in several directions until the desired finish is obtained. Deep marks in the tip should first be faced out on a lathe.

The lapped bushing generally used to prevent leakage along the stem has not yet come into general use for this type of spray. Polished drill rods are in general use for needles and are used in their ordinary commercial finish. This necessitates packing. Cut rings and braid are used with petroleum-resisting impregnation combined with graphite or plumbago. Nothing that will disintegrate into metallic flakes or particles has yet been successful, as the débris works down into the spray.

To tighten the packing automatically while in service, the bottom of the stuffing box is provided with a loose follower which is under the fuel pressure. The piece is faced with a deep outward chamfer, opposite to the usual practice; this tends to prevent the escape of packing inward or outward. The friction for $\frac{1}{4}$-in. stems at 5,000 lb. fuel pressure is only twelve to thirteen pounds.

How to Set the Spring

After loose assembly the spring is adjusted. The coarse adjustment is made by giving the adjusting screw a definite number of turns, but as the springs are too rarely calibrated, the actual adjustment should be made in one of two ways. The spring may be set so that the spray-valve stem is lifted by a predetermined pressure per square inch, usually 6,000 lb. This cannot be done by the usual method of connecting the spray for test to the manifold of a running engine, for such a pressure would lift all the engine sprays, causing them to discharge continuously. It must be done by means of an independent motor-driven or hand-operated test pump. Another method, not in as frequent use as it deserves, includes the use of a weighted beam or steelyard.

The proper spring compression should be determined by the maker. For one-fourth-inch needles it is usually 525 to 550 lb.; for one-half-inch needles it is 2,000 to 2,500 lb. It should never be more than actually required, as the seat in the tip is usually highly stressed, particularly when the fuel pressure is low.

The real necessity for accurate spring adjustment is most evident in the older type of spray valve, Fig. 1. The slender needle reaches great length in the large engines and, when seated, is an unstable column under the spring load superimposed on it. It buckles until it contacts with the walls of the clearance hole in the body. The beam *e* so often used to lift the spray deflects more or less; if made heavy, it may open the spray by percussion, which must be avoided. These two major deflections and other lesser ones vary with the spring loading and the fuel pressure. All the spray mechanisms on an engine should deflect the same amount; otherwise, with a change of load, readjustment of all spray cam clearances will be required to even up the loading of the cylinders.

A set of carelessly adjusted sprays revealed on investigation the following spring settings:

Spray No.	Spring Compression, Lb.
1	759
2	404
3	489
4	379
5	224
6	504

This represents a total difference of 535 lb. The mechanism deflection for this particular engine is about 0.003 in. per 100 lb. The resulting difference in spray lift would then be 0.016 in. As the lift is always associated with the timing, the lightly loaded spray would not only lift higher, but would remain open much longer. The heavily loaded spray would, perhaps, not lift at all under light load, causing that cylinder to cut out. Furthermore, as the spray spring furnishes the accelerating and retarding force for the whole actuating mechanism, the lightly loaded spray needle, requiring practically all its tension to balance a fuel pressure of 4,000 lb. per sq.in., would not be able to follow its cam. This results in a still greater excess in fueling of that cylinder, with danger of a runaway engine.

Improved Valve Gear

Modern mechanisms, such as Fig. 2, are more direct, lighter and stiffer, therefore less sensitive to the spring adjustment. The spring is usually so placed that the needle is under tension when lifted by the lever *A*, Fig. 4, and is not stressed at all when seated, except at the short lower end. Nevertheless, a reasonable accuracy of spring adjustment is required.

The fuel manifold is fitted with an isolating valve for each spray. It is then possible to shut off the fuel from a spray while the engine is running. It is inadvisable to operate for long periods in this condition, for it batters the seats badly. To seal against 4,000 to 5,000 lb. oil pressure, the force holding the needle to its seat must be in excess of that pressure and is often made as much as four times as great. At the time when the fuel pressure is removed, the seat stress, already high, is raised beyond the continued endurance of the metal and it flakes out. For this reason any spray that must be isolated during a run should also be thrown out of operation by backing off the nuts engaged by the lifting mechanism.

Preventing Leaks

The practice of twisting the needle on its seat in an endeavor to stop leaking should also be discouraged. Some sprays are fitted with a broached preventer fitting over the guide wings so that it is impossible to turn the needle in place. When it is so turned, the seat becomes a step bearing loaded with 20,000 lb. or more per square inch and is easily abraded.

In addition to testing for spring tension, the spray should be tested for tip seat leakage under working pressure. This may be done by attaching the spray to a fuel-manifold test connection usually provided by the engine builder. The spray is clamped in a bracket and operated by a hand lever. It should close promptly without after leakage. Aside from prompt and complete

shutoff no attempt need be made to judge the quality of the oil spray, as it cannot be much altered, being governed entirely by the shape of the drilled hole.

The adjustment of the oil sprays consists of nothing more than making the cam-roller clearances or the needle-lifter clearances all alike. These clearances vary with the size of engine, from 0.010 to 0.025 in. The engine is then set in operation under load and some tuning is done with the help of the exhaust pyrometers. If the spray operating mechanism is a good one, little tuning will be required. But be careful that all the cam-roller clearance is not taken up. It is better to lighten the other cylinders a bit, forcing the lazy one to take up some load. If it proves impossible to get a cylinder up to its work, it is quite certain that its spray is plugged and must be cleaned. Detonation in any one cylinder indicates that a leaking spray valve is allowing oil to flow in continually.

An Adjustable Cam

The spray cam is slotted to permit shifting the nose. It usually gives a maximum dwell covering about 30 deg. of crank travel, 20 deg. of this being under governor control. Settings vary from admission before dead center of from six degrees for good fuel and moderate speeds to fifteen degrees for higher speeds or heavy fuel. The usual practice is to set the cam so that the maximum cylinder pressure at full load is from 550 to 600 lb. per sq.in. for engines at ordinary speeds and 750 lb. for very high speeds. If the quality of fuel purchased is fairly uniform, little if any adjustment of timing is called for. Cams are set by charging the fuel manifold with the hand priming pump and noting the fall of the pressure gage when a spray opens while the engine is turned with the barring gear.

The fuel cam nose is originally sharp but soon takes on a small radius. If the material is good and the heat treatment and grinding carefully carried out, the cams give practically no trouble. However, an occasional imperfect cam rounds off too much at the nose and must be replaced, or the cylinder served by it will get no fuel at lighter loads.

For removing the tip without releasing the spring tension, a sleeve like that shown at *e* between the stuffing box and lifter nuts *d* in Fig. 2 is useful.

Recently Developed Refractories May Prove Useful

HIGHER rates of heat release, higher furnace temperatures and more severe conditions encountered in modern boiler installations make improved furnace construction necessary. This has in some cases resulted in the adoption of water-walls. Air-cooled refractory walls have been used elsewhere. There are many cases, however, in which a solid refractory wall would be more desirable if one could be provided that would withstand the severe service conditions.

Recent research has developed several new types of refractories. Of those that have been used commercially, the most promising appear to be the aluminous types, primarily diaspore and mullite.

Diaspore refractories are made from native diaspore clays. The diaspore (hydrated alumina) in this material, when subjected to continued high temperatures, slowly changes to alpha corundum, a substance of greater density, thereby causing shrinking. This fault can, however, be overcome if a sufficiently high temperature is used in making the brick. At present the brick is not prepared in this manner. Consequently, the diaspore refractories do not have as wide application as may be attained after further research and development.

Mullite refractories are of several types. In all these the principal material is mullite, a silicate of aluminum of the formula $3Al_2O_3:2SiO_2$. This mineral imparts to the brick qualities of high refractoriness, constancy of volume and rigidity at high temperatures.

Mullite is by no means a new constituent of furnace brick, for it is the material that develops in ordinary firebrick when brought into contact with furnace slags. It imparts to these brick their good qualities under service conditions. The new mullite refractories are the results of attempts to produce brick having a higher content of this mineral than the ordinary fireclay product.

They are of two types: Those made from a mineral such as andalusite, cyanite or dumorterite; and those made in the electric furnace by fusing the correct proportions of alumina and silica.

The Bureau of Mines has conducted tests on refractories made from a mixture of cyanite and diaspore clay, reported by H. C. Harrison in the "Journal of the American Ceramic Society" for 1926, page 257 and following. In a boiler furnace fired with Illinois coal, brick in the side walls did not spall to any extent and slag did not penetrate beyond the surface. Slag erosion was found to be less than that experienced with high-grade flint fireclay brick. These tests show that the advantage of this diaspore-cyanite brick over diaspore brick was due to the mullite content.

One caution that will apparently need to be observed in applying mullite refractories is to prevent contact between them and slags bearing iron oxide. This latter substance is taken up by the mullite, with a consequent lowering of its melting point.

Success obtained in the use of mullite refractories in glass-melting tanks, particularly with the electric-furnace product, promises utility for this material in a wide field. It is not possible yet to tell what application can be made to boilers, if any; but research is under way that should make this information available in the future.

According to a recent report of the Department of the Interior, Canada, Dominion Water Power & Reclamation Service, Ottawa, the year 1928 was one of the greatest in the history of water-power development in the Dominion. During the year waterwheels aggregating more than 550,000 hp. were installed. This brings the total for the Dominion to 5,328,000 hp. There were many large undertakings under active construction, some of which were nearing completion at the end of the year, while others were in their initial stage. These have a total capacity of more than 1,200,000 hp. There are also many large developments in prospect, a number of which will undoubtedly be started in the coming year. During 1928 every province was represented in the year's activities, and while Quebec stood first in works of magnitude, the widespread nature of development is perhaps the most interesting and significant feature. Saskatchewan appears for the first time with a hydro-electric project under way on the Churchill River for the supply of the new northern mining area, while British Columbia, Alberta, Manitoba, Ontario and the Maritime Provinces are all represented.

POWER HOUSE CRANES

Require Close Speed Control

By R. F. EMERSON

Industrial Engineering Department, General Electric Company

WITH many kinds of cranes it is necessary to raise or lower loads at very slow speeds. Cranes in power houses must place expensive machines carefully and accurately on to their foundations. Cranes in shipping departments, where fragile products are handled, must hoist and lower without causing breakages. In foundries it is necessary to lift copes carefully from rest and place them on the drag without jarring. In these and in many other similar applications it is imperative that there be no sudden increases or decreases of torque such as obtains when cutting a large block of resistance in or out of circuit.

Solenoid load brakes have been used on cranes with alternating-current motors for a wide variety of uses. The hook speeds with which they are used vary from 15 to 200 ft. per min., and the hoist motor sizes range from five to 200 hp. at 900 r.p.m., which shows broad range of applications for these brakes.

Solenoid load brakes are similar to the ordinary solenoid brake, except two solenoids are used instead of one for the latter. One of the solenoids is connected across one phase of the primary winding of the wound-rotor induction motor and the other across one phase of the motor's secondary. The resistor for acceleration and speed control is laid out so that 25 per cent of full-load torque of the motor is obtained at standstill. It is the combination of motor torque and brake retarding torque that gives the speed control for the crane hoist hook.

When an empty hook is being hoisted, the speed of direct-current series hoist motor increases. An induction motor is a constant-speed machine. If an alternating-current and a direct-current motor are geared to lift an average load at the same speed, the series may hoist an empty hook at more than double the speed of the alternating-current motor. To do as much work in the same time with the alternating-current motor it should be geared to operate a little more than the average speed of a series motor when running loaded and without load on the hook.

If the induction motor hoists at a higher speed than the series motor, a larger motor must be used because of the increased horsepower required. Also, since an induction motor is limited in torque, it will be stalled by an extra-heavy load, whereas a direct-current series motor will continue to pull the load at a correspondingly lower speed. The torque of the direct-current series motor is limited only by its ability to commutate heavy current.

Low voltage on alternating-current circuits reduces the motor's torque in proportion to the squares of the voltage. The torque of a direct-current motor is not affected by low voltage. Therefore, when selecting an induction motor to handle a load, allowance should be made for possible low line voltage and the motor's torque limitations. With a series motor it is possible to get a stable creeping hoisting speed on the first point of the controller by shunting resistance around the motor's armature. This is indicated by curves 1 and 2, Fig. 1. These curves show that about 10 per cent full load can be hoisted with good stability at 30 per cent full-load speed. In Fig. 2, which is for an induction motor, curves 2 to 8 cover the motor characteristics obtained with the usual type of control. With 10 per cent load the slowest speed obtainable is about 80 per cent of synchronous speed.

Cranes for power houses and many other services must have motors and control that will handle loads at very slow speeds. Direct-current series motors arranged for dynamic braking are compared with wound-rotor induction motors using solenoid brakes for slow-speed operation.

By using a solenoid load brake, it is possible to obtain creeping speeds, curve 1A, by inserting resistance in series with the connected solenoid. When the motor is energized, both cores of the brake tend to lift, thus reducing but not removing the braking effect. The resulting load holds the motor at a low speed even with a small load on the crane hook. The motor may be jogged one twentieth of a revolution. With a crane geared for 30 ft. per min. and using a 900-r.p.m. motor, one-twentieth of a revolution moves the hook only 0.02 of an inch. This shows that by using a solenoid load brake, it is possible to hoist light loads slowly with an induction motor the same as with a direct-current series motor.

When lowering loads, the speed of an induction motor ranges from slightly below synchronous speed to almost any value above this speed, depending on the load and the amount of resistance in the rotor circuit. Conse-

quently, an induction motor not equipped with a solenoid load brake will have a series of speed-torque curves comparable to 5A to 8A, Fig. 2. By using a solenoid load brake it is possible to obtain operation indicated by curves 1A to 4A. These show that 10 per cent full-load can be lowered at speeds ranging from 10 or 15 per cent of synchronous speed and higher. Induction-motor curves 1A to 4A, Fig. 2, cover the same area as the series-motor dynamic-braking curves 1′ to 4′ and 4A and 4B, Fig. 1.

For the usual class of work, drum controllers should be satisfactory with either direct or alternating-current motor operated cranes. Operation cycles are not usually fast enough to require magnetic control. If the motors are large and the voltage is low, it may be desirable to consider magnetic control because of the large current. If the maintenance of both control and motor is to be kept at a minimum, full magnetic control may be used. With magnetic control it is desirable to inclose the contractor panel.

Dynamic braking with series motors is obtained without frictional wear such as is caused by wear of the shoes on a brake wheel. Braking induction motors with a solenoid load brake occurs only at lowering speeds less than synchronous. When lowering at full speed, the solenoid load brake is entirely released and the load is

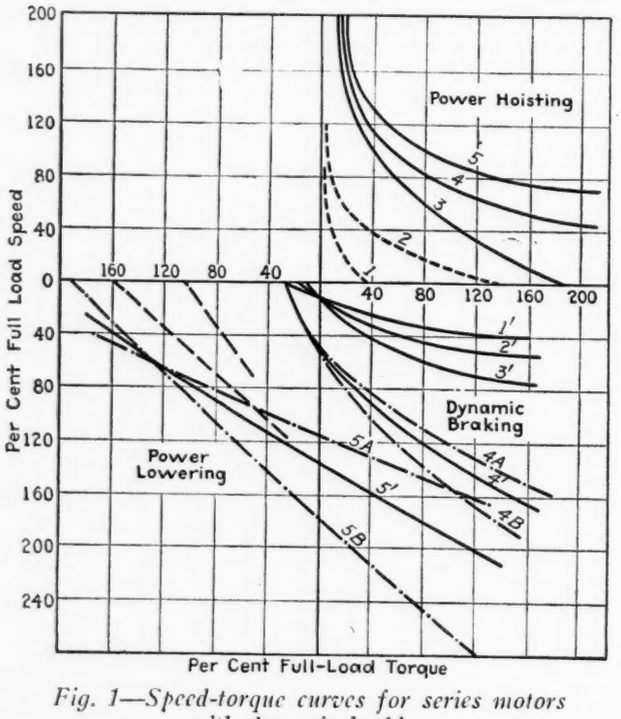


Fig. 1—Speed-torque curves for series motors with dynamic braking

The curves in the power-hoisting quadrant represent the speed-torques for hoisting loads on the crane hook. Curves 1 and 2 are obtained with a resistance in parallel with the armature. Curves shown in the dynamic-braking quadrant give speeds and torques at which the motor operates dynamic braking to hold a load in control. In the power-lowering quadrant, the curves are for lowering loads under conditions that require power from the motor.

held in control by the motor acting as an induction generator, returning power to the line. Thus, when lowering loads by this method, there is no wearing of the brake shoes except when running at reduced speeds. The action of the solenoid load brake is different in this respect from the usual mechanical load brake which requires power from the motor when lowering a load at any speed. With the usual mechanical load brake the motor takes power from the line at all times when lowering loads, and the wear between brake shoes and wheel is continuous while the load is being lowered.

Considering the motors and control, the upkeep of the alternating-current will be less than that of the direct-current equipment because of the absence of commutator and brushes. Alternating-current motors with magnetic control entail the least maintenance expense.

In cases where direct current is available, series motors

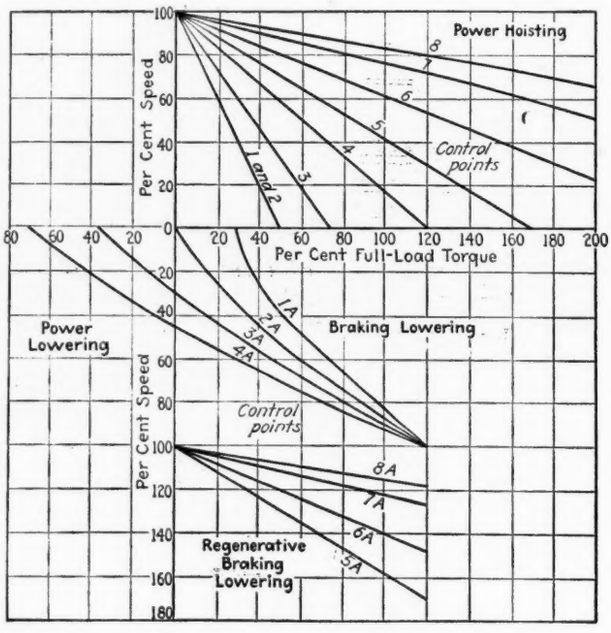


Fig. 2—Speed-torque curves for wound-rotor induction motors with solenoid load brake

In the power hoisting quadrant the speed-torque curves are obtained when hoisting a load on the hook. The braking-lowering curves are those obtained when lowering a load by applying the solenoid load brake. Power-lowering curves are those obtained when power is applied to lower the load. The regenerative-braking curves are obtained when the motor is operating as a generator to keep the load under control. In this case the motor always operates above synchronous speed.

with dynamic-braking control with one creeping-speed point obtained by shunted armature connection in the hoisting direction, will give the most flexible control. Where only alternating current is available and a high initial investment in motor-generator sets is required to get direct current, crane-type induction motors with solenoid load brakes should be given careful consideration.

Baking electric machines in an oven is the best practice to dry them out. It is essential that the oven be well ventilated in order to get rid of the moisture driven out of the windings. If the oven is not ventilated, it will be found impossible to dry the windings, and overlooking this point is frequently the cause of difficulty in restoring the insulation to normal. One of the best checks on how the drying process is progressing is to test the insulation resistance. If it is found that the insulation's resistance is slow in returning to normal after eight or ten hours' baking at a temperature of about 200 deg. F., it will be well to look carefully into the ventilation of the oven. Where machines have been submerged in water while running, it will generally be difficult to restore their insulation qualities by baking and rewinding will usually be necessary before the machine will be fit for service again.

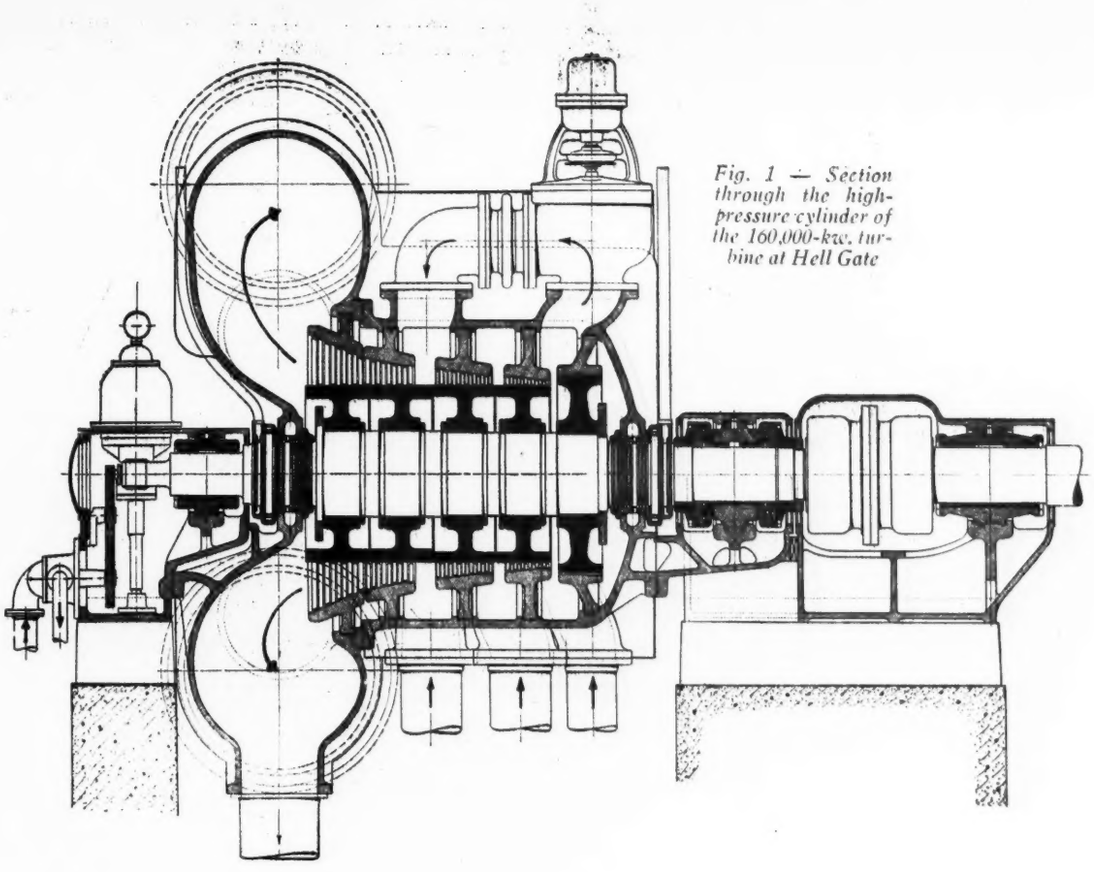


Fig. 1 — Section through the high-pressure cylinder of the 160,000-kw. turbine at Hell Gate

160,000-Kw. Unit

Goes into Service at the

HELL GATE STATION

THE giant 160,000-kw. turbine generator installed in the Hell Gate plant of the United Electric Light & Power Company is now the largest unit in operation. At the time of its purchase from the American Brown Boveri Electric Corporation its capacity was the maximum offered for a machine capable of being installed in the limited space available, which was approximately 38x76 feet.

This unit is a cross-compound machine consisting of a high-pressure unit running at 1,800 r.p.m. and a low-pressure unit running at 1,200 r.p.m. Its maximum output is 160,000 kw., with the most economical point at 90,000 kw.

Steam at 265 lb. pressure and 200 deg. superheat is supplied to the turbine through two parallel steam lines. The steam chest carries the two main stop valves, which are furnished with bypass valves. The admission of steam to the turbine is controlled by two parallel primary, two parallel secondary and three parallel tertiary valves. The primary and secondary valves are on top of the steam chest and each is connected to the turbine cylinders through pipe lines running below the floor level. Two of the tertiary valves are below the operating floor level and take steam direct from the secondary-valve steam lines, and the third tertiary valve is placed on top of the high-pressure turbine cylinder and bypasses steam from the first to the third section. The main stop-valves have a diameter of approximately 23½ in., the primary 15½ in. and the secondary and tertiary valves, 19½ inches.

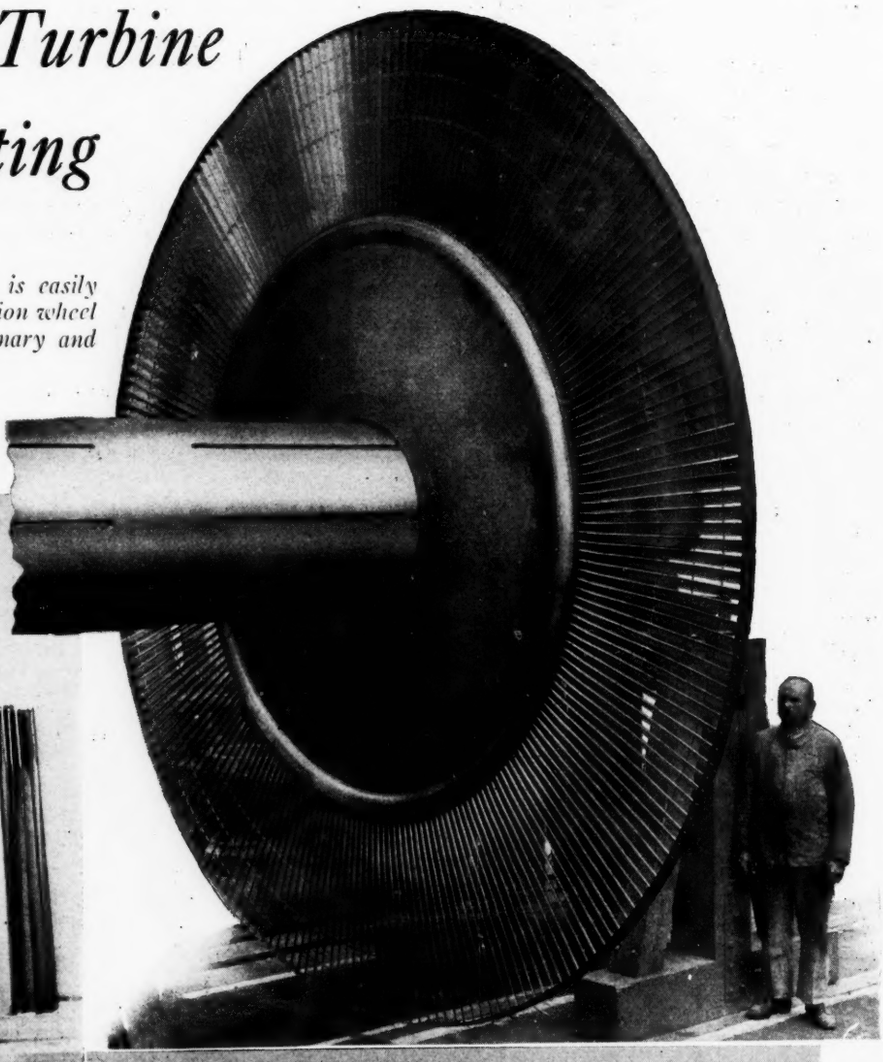
The primary valve takes the unit up to a load of 50,000 kw., the primary and secondary valves up to 90,000 kw., and at 160,000 kw. all seven valves are open. At maximum load 1,710,000 lb. of steam per hour will be admitted to the turbine when running non-bleeding. This corresponds to 77 long tons of steam an hour or to approximately 3,600 gal. per min. of boiler-feed water.

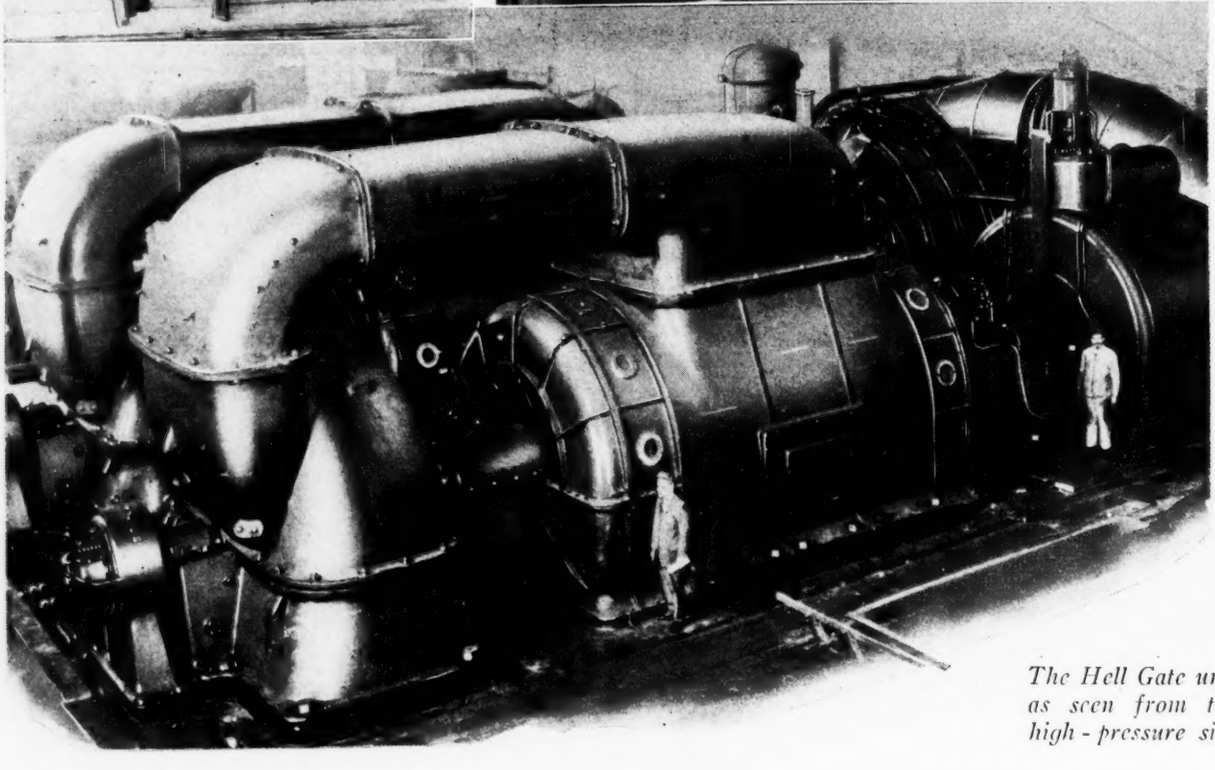
Arrangements are made for two-stage bleeding. Steam for the high-pressure heater is bled from the exhaust of the high-pressure cylinder and for the low-pressure heater from after the fourth low-pressure stage.

The turbine cylinder is of cast steel and forms the

The Largest Turbine Now Operating

The immense size of this turbine is easily judged from the low-pressure reaction wheel shown at the right and the stationary and moving blades shown below





The Hell Gate unit as seen from the high-pressure side

outer shell of a built-up inner cylinder that carries the guide blades, dummy piston and labyrinth packing. This construction gives to the outer cylinder shell, as well as to the inner cast-steel cylinder elements, a simple form that lessens the possibility of appreciable distortion due to internal stresses in the material.

The blading, which is of the reaction type, is divided into three sections. Up to loads of 50,000 kw. steam is admitted only in front of the first section; above this load the first section, consisting of six stages, is bypassed, and at 90,000 kw., is almost completely cut out. Above 90,000 kw. the second section, containing seven stages, is also bypassed, and at 160,000 kw. both the first and second sections are almost entirely cut out, and the total work is done in the third section, consisting of only nine stages. At full load the output of the high-pressure unit is 72,000 kw., the remainder of 87,000 kw. being carried by the low-pressure unit.

Four Drums Carry Rotating Blades

The turbine spindle is built up of five short drums keyed to the shaft. The drums are a sliding fit on the shaft and each is held in position by means of two elastic rings. Four of these drums carry the rotating blades, while the fifth at the inlet end of the turbine, is a dummy piston that carries the major part of the actual thrust. With this built-up arrangement of the spindle the steam has contact with a large amount of spindle surface and, therefore, heats it rapidly. Through this means the starting-up period is greatly reduced.

The blades are of stainless steel and are fastened to the drum as shown in Fig. 3. The blades are kept in

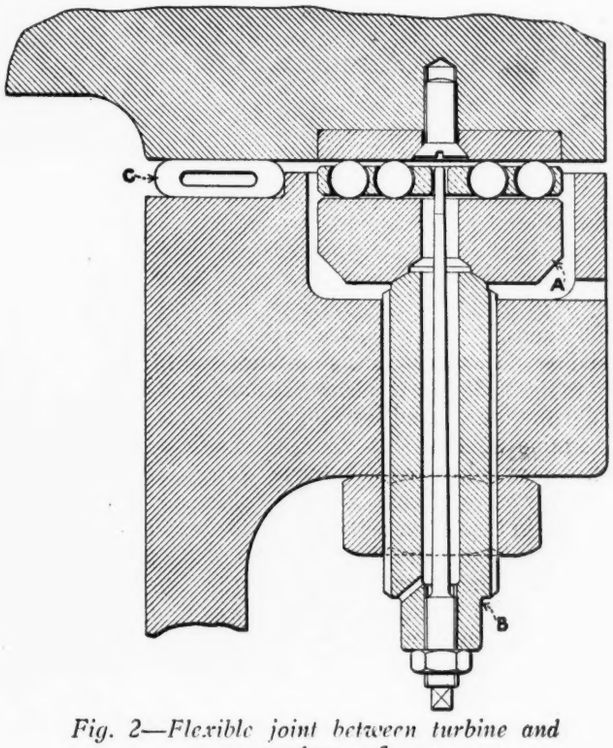


Fig. 2—Flexible joint between turbine and condenser flanges

place by distance pieces *A* that bear against T-sections formed on the roots of the blades. The distance pieces have serrations that fit into corresponding notches in the drum. The advantage claimed for this type of blade fastening is that the uniform cross-section eliminates concentration of dangerous stresses at the root of the blade.

To avoid any danger of rubbing between the blades and the cylinder, the tips of the blades have been sharpened to a knife edge. The blading is strengthened with lacing wire, silver-soldered to the blades.

The shaft glands are designed to be either steam- or water-sealed. They consist of a small impeller that rotates with the shaft and forms the water-seal end of a labyrinth packing which is for the steam sealing. The labyrinth-packing strips are integral with a steel bushing that is keyed to the shaft and surrounded by a stationary

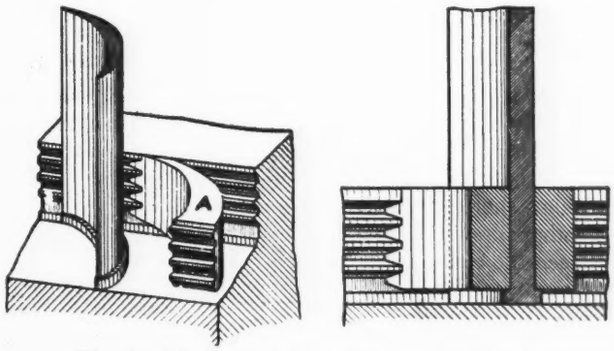


Fig. 3—Method of fastening moving blades

steel bushing elastically connected to the turbine cylinder.

At the rear end of the turbine, which is the steam admission end, there is a combined thrust and journal bearing. The thrust bearing carries any thrust not taken up by the dummy piston and is of the Michel-Kingsbury type. In order to secure an even distribution of the load over all the segments, each is supported on two steel balls which at the same time support adjacent segments. In this way, if one segment is carrying more than its fair share of the load, it forces apart the two balls supporting it, and in doing so forces up the adjacent segments, which then take a greater load until the load has become evenly distributed.

Low-Pressure Turbine Cylinder

Steam enters the low-pressure cylinder at a pressure that varies with the load and that is approximately 23 lb. per sq.in. at full load. The turbine is designed for double flow and discharges into a single condenser through two exhaust openings.

In order to avoid any stresses due to differential expansion of condenser and cylinder, one exhaust flange is bolted up solid to the turbine, but the face of the other exhaust flange is free to move relatively to the turbine on ball-bearing supports. The joint at the free flange is made as shown in Fig. 2. It consists of a number of ball bearings at equal intervals around the whole circumference of the exhaust flange. Each ball bearing is supported by a steel disk *A* that can be adjusted by the bolt *B*. The balls are held in place by a cage which, however, allows sufficient lateral motion. All parts making up the joint are chrome-plated to prevent rusting. The joint is made airtight by a hollow rubber ring compressed between the two flanges. Water under pressure may be circulated through the ring to insure airtightness.

Between the ball bearings are intermediate bolts adjusted with small clearance under their heads. These bolts keep the flange from spreading when there is no vacuum and the compression force between them is absent.

The low-pressure spindle is built up of fourteen disks, seven in each half, which are keyed to the shaft and held in position by elastic rings. The shaft itself is 33½ in. in diameter, 26 ft. long, and weighs, without disks, over 25 tons. It is bored throughout its length, the diameter of the hole being 15¾ in. at the center and 7⅞ in. at the ends. During manufacture it was first of all forged down to the smaller diameter at only one end, which was bored out to the proper diameter. The other end was bored out to 15¾ in. diameter. This allowed the inside of the shaft to be inspected by a metallurgist who crawled along inside the bore. After inspection the end which had been bored out to 15¾ in. was forged down to the correct outside diameter and the bore again machined to the proper size.

Each half of the low-pressure turbine consists of eight reaction stages. The first two rows of running blades are mounted on the same disk, and each of the remaining seven rows is carried separately on one disk. The hollow shaft and disk construction results in more even heating, shortens the starting period and makes for smoother operation by reducing the time differential between the expansion of the two elements. The spindle has an over-all diameter of approximately 13 ft. and weighs over 80 tons.

To eliminate any possibility of rubbing, the clearances between the fixed and moving parts have been made exceptionally large. The usual heavy leakage losses resulting from large clearances have been minimized by the shape of the blade spacer pieces, which direct the steam across the gap between the blades in such a way that little of it leaks around the tip of the blading.

Oil and Governing System

Two main oil-supply pumps are driven through gears by the high- and low-pressure spindles and deliver a total of nearly 800 gal. per min. to the four components of the oil system. During starting up and shutting down a steam-driven auxiliary pump supplies the oil for lubrication and valve operation.

Low-pressure oil is supplied to the lubrication system mainly by the pump driven from the low-pressure spindle. Excess oil from the high-pressure pump is also made available for lubrication through an orifice connection to the low-pressure system. Before going to the bearings, the oil passes through four coolers that have a total cooling surface of 1,900 square feet.

High-pressure oil is supplied by the pump driven from the high-pressure spindle, through pilot valves to the operating pistons of the governing valves. The pilot valves are operated by oil supplied from the high-pressure system through a needle reducing valve. The pressure of the oil determines the position of the pilot valves and is controlled by the relay of the centrifugal speed governor. This governing system is also connected to a vacuum limiter which releases the oil pressure as soon as the vacuum falls below 10 in. In this way the machine is automatically shut down in order to avoid the high temperatures that would result from running at low vacuums.

An emergency system supplied with oil through a needle valve is connected to two large release valves that are operated by the overspeed governor of the high- and low-pressure turbines. Thus, if either of the turbines overspeeds, the corresponding release valve is opened and the main stop valve closes immediately.

For starting and shutting down, a small controller is provided, which first closes the emergency system and thereby opens the main stop valve. It next controls the oil pressure in the governing system until the unit is up to speed.

The two generators are rated respectively at 88,200 and 100,000 kva. at 1,800 and 1,200 r.p.m. Air for ventilation is supplied by two blowers direct connected to the generator shafts. Because of the relatively high speed at which they operate, the fan impellers have been made of a magnesium alloy in order to make them as light as possible. Each generator, with its blower and cooler, forms a closed circuit, and their relative positions made it possible to reduce the volume of cooling air to a minimum, the amount actually needed being 127,000 to 137,000 cu.ft. per min. for each generator. The air enters the generators from below and passes out at the top through ducts connected to the fans. The fans force the air through the coolers, which are mounted in the foundation, and from here the air returns to the generators. The construction of the housing and lamination is such that the air passes through the stator iron in a large number of parallel ducts and also over the surface of the rotor. The end connections of the rotor and stator windings are cooled by air taken in by ducts at the ends of the alternators.

The limitations imposed on the designer by the confined space available for the unit decreased to some extent the turbine efficiency that might otherwise have been obtained. In spite of the limitations an efficiency at the couplings of the turbines of 84.5 per cent was guaranteed. When the unit is operating at 90,000 kw. with feed-water heating, the guaranteed heat consumption of the unit is 11,750 B.t.u. per kw.-hr., which corresponds to a thermal efficiency of 29 per cent from steam at the main stop valve to the switchboard.

Selecting Ammonia Condensers

IN SELECTING the proper type of ammonia condenser, it is important to consider both the summer and winter conditions. When cold water is available, shell condensers are efficient. Being located at the ground level, pumping costs are reduced. Recently, in a plant where 52-deg. well water was available, the condenser was placed in the engine room, so that the pumping head for the water was less than 25 lb. Formerly, with atmospheric condensers on the roof of the four-story building, the ammonia head pressure was 135 lb. Changing to the shell-type condenser reduced it to 115 lb.

On the other hand, careful analysis must be made to determine whether shell condensers will pay during the entire year where cooling-tower water is used. There are many cases where a reduced volume of water can be pumped in the winter season, and, furthermore, the benefit obtained from the atmosphere as a cooling medium is lost when condensers are placed in the engine room not equipped with forced-air circulation.

Investigation of many atmospheric condenser installations has shown that air circulation and proper venting of the condenser loft are important. In a refrigerating plant in New York City the ammonia condensers were placed so that air circulation was impaired. A wall was on one side, a large penthouse on another side, and a party wall extended on the third side. Fortunately, the windward side was free and open, but as the condensers were so well inclosed on the other sides and a staggered-louvered roof extended over the top, the vapors from the condenser did not carry away as they should.

SIX MONTHS

From Breaking Ground to Current on Switchboard

Record Accomplishment in the Erection of 18,750-kva. Steam Station at Lake Pauline, Tex.

By R. B. Niese, Jr.
West Texas Utilities Company

ON FEB. 13, 1928, work was begun on the Lake Pauline Station of the West Texas Utilities Company, six miles southeast of Quanah, Tex. Six months later the station began generating electricity, and on Sept. 10, 1928, the first unit of 18,750 kva. capacity was placed in service.

Location of the plant was determined by the fact that water for circulating purposes is limited in this section of the state, and Lake Pauline, which had been constructed a number of years ago as part of an irrigation project, offered a suitable supply.

Natural gas is burned under the boilers. This is supplied from the Panhandle gas fields through an 8-in. high-pressure main and is delivered to the burners at 18 lb. As auxiliary fuel oil will be used, a ten-thousand-barrel storage tank is being provided. Oil is unloaded by means of a motor-driven screw pump having a steam-jacketed cylinder. From the storage tanks it will be delivered to the burners by two turbine-driven pumps after passing through a heater.

The boilers face the outside east wall and immediately behind are the heaters and evaporators and adjoining this space is the turbine room. There is no wall between the boiler and turbine rooms, and the operating room is on the west side of the turbine room. Extension to the plant is to be made on the south, and a temporary end wall of steel and four inches of brick was constructed. The steel framework of the building begins at the basement floor level, simplifying any future change to pulverized coal.

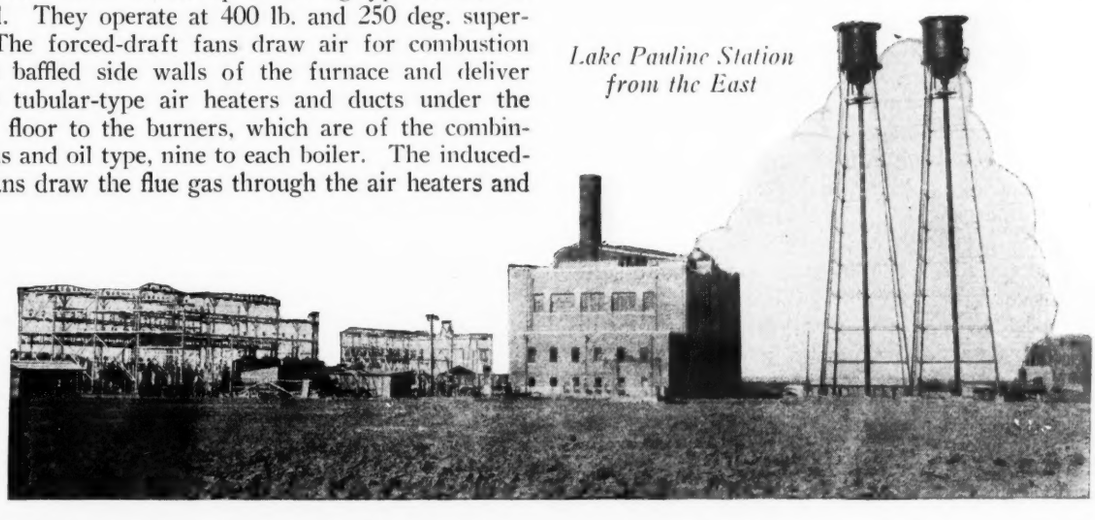
At present three 10,000-sq.ft. Stirling-type boilers are installed. They operate at 400 lb. and 250 deg. superheat. The forced-draft fans draw air for combustion through baffled side walls of the furnace and deliver through tubular-type air heaters and ducts under the furnace floor to the burners, which are of the combination gas and oil type, nine to each boiler. The induced-draft fans draw the flue gas through the air heaters and deliver it to a single steel stack, 10½ ft. in diameter and extending 53 ft. above the roof.

Duplicate two-stage hotwell pumps are provided. These are direct-connected to variable-speed motors. A twin steam-jet air pump with inter- and after-condensers is installed.

The turbine is of 18,750 kw. capacity at 100 per cent power factor when bleeding sufficient steam for heating its own feed water. Steam conditions at the throttle will be 375 lb. gage and 700 deg. Ten per cent of the throttle flow may be extracted from the first, fourth and sixth stages and 7 per cent from the eleventh stage. Steam is extracted from the first stage at 101 lb. gage and from the fourth stage at 48 lb. This is used in heating the feed water in two vertical high-pressure heaters. Steam from the sixth stage at 22 lb. gage maintains 5 lb. gage pressure in an open-type deaërating feed-water heater and also supplies a double-effect contraflow evaporator of the submerged coil type. Steam from the eleventh stage at 5.4 lb. absolute is used in a floating-head type low-pressure heater.

With 1 in. back pressure and at full load, it is estimated that the condensate will leave the condenser at 80 deg. and pick up 10 deg. in the air cooler, 25 deg. in the low-pressure heater, 40 deg. in the evaporator condenser, 70 deg. in the open heater, 60 deg. in No. 1 high-pressure heater and 40 deg. in No. 2 high-pressure heater, and enter the boiler at 325 deg.

The feed water is handled by three pumps, one motor-driven six-stage, one turbine-driven six-stage, each of



Lake Pauline Station from the East

250 g.p.m capacity, and one five-stage turbine-driven pump having a capacity of 500 g.p.m.

Service water is handled by two 400-g.p.m. motor-driven pumps.

There are two 25,000-gal. tanks on 125-ft. towers, one of which is used for service water and the other for distilled water. The raw water for the plant is treated in a "zeolite" water softener before evaporating.

Circulating water which flows from the lake through an open flume into the intake well 50 ft. from the building, is handled by a 36,000-g.p.m. motor-driven pump and enters a 17,000-sq.ft. single-pass condenser. The discharge is carried under the boiler-room floor to the discharge well on the opposite side of the building. A canal carries the water from the discharge well to a neck of the lake northeast of the plant. The condenser tubes are of arsenical copper and are expanded at both ends, one tube sheet being full floating. An external air cooler of 2,000 sq.ft. is used in connection with the condenser.

Compressed air is supplied by a two-stage air compressor having a capacity of 425 cu.ft. per min. This compressor is connected by a multiple rope drive to a 125-hp. ball-bearing motor.

Electricity is generated at 13,800 volts.

The station will have a complete machine shop located in the turbine room and boiler room basements. Its equipment includes an 18-in. lathe, an 11-in. lathe, a 24-in. drill press, an emery grinder and a portable crane and hoist.

MECHANICAL EQUIPMENT, LAKE PAULINE STATION

Company	West Texas Utilitie
Designing engineers	Sargent & Lundy
Initial capacity	18,750 kva.
Boilers	Three 1,000 sq.ft. B & W Stirling
Furnaces	M. H. Detrick, air cooled
Burners	"Benster" combination oil and gas
Forced draft fans	Sturtevant, "Turbovane"
Air preheaters	Babcock & Wilcox, tubular type
Stack	Mosher Steel & Machinery Co.
Oil storage tank	Wyatt Metal & Boiler Works
Flues and ducts	Wyatt Metal & Boiler Works
Flue insulation	Johns-Manville Co.
Oil pumps	"Quimby," driven by Terry turbines
Oil heater	Griscom-Russell, five pass norizontal
Feed water regulators	"Copes" (Northern Equipment Co.)
Draft gages	Lewis M. Ellison
CO_2 meters	Brown Instrument Co.
Steam flow meters	Builders Iron Foundry
Thermometers, recording and indicating	The Bristol Co.
Valves (non-return, globe, check)	Edward Valve Co.
Valves (steam and boiler-feed gate valves)	Walworth Co.
Valves (motor-driven circulating-water valves)	Crane Co.
Pump regulators	Mercon Regulator Co.
Piping	Urbauer-Atwood Co.
Pipe covering	Standard Asbestos and Insulating Co.
Steam turbine generator	One 18,750 kva. a General Electric
Generator air cooler	General Electric
Condenser	17,000 sq.ft. single-pass, Foster-Wheeler
Hotwell pump	Duplicate two-stage, Foster-Wheeler
Steam-jet air pump	Wheeler
Bleeder heaters—high-pressure	Foster-Wheeler
Bleeder heaters—6th stage	Cochrane open type, deaerating
Bleeder heaters—11th stage	Horizontal, Wheeler
Evaporator	Wheeler double-effect contraflow
Feed pumps	One 6-stage motor-driven 250 gpm — Cameron One 6-stage Terry turbine-driven, 250 gpm — Cameron One 5-stage Terry turbine-driven, 500 gpm — Cameron
Water-storage tanks	Two 25,000 gal. on 125 ft. towers (Chicago Bridge & Iron Works)
Water treatment	(zeolite) International Filter Co.

Buying for Price or Quality

By Abraham Davidson

QUALITY should never be sacrificed for price. Purchased material should be considered from the viewpoint of its quality rather than its comparative cheapness. The price of the article and the service of the seller fade into insignificance when the quality of the item is disregarded.

Yet the fact seems to be that the average individual hesitates paying more for an article of superior quality when he can buy one of slightly inferior quality and workmanship for 10 or 20 per cent less.

The solution to this problem might be affected if the purchaser were permitted to make payment for the item purchased in a number of installments over a reasonable period. If such were the case, the price of the article would lose its importance and quality would be of prime consideration. The better article would therefore be chosen. It has been proved, in many instances, that where too much attention has been given to the matter of prices at the sacrifice of quality in connection with the purchase of goods, such a policy has proved disastrous when carried to its logical conclusion.

Goods should be bought first of all on quality and past performance. However, in the case of purchasing mechanical equipment many equipment manufacturers complain of the prevailing buyer's market, with its price-cutting. The aim of every purchaser should be to secure the lowest price, most favorable terms and most adequate service, consistent with the most satisfactory quality. Frequently, goods are offered at a low price merely with a view of getting the order. After the price has been accepted, the seller may fall down seriously on deliveries and service, even though the specified qualities may be maintained. Under such circumstances, however, unless quality has been clearly specified in writing, there is danger that substitutes may be offered. Not uncommonly, new producers underbid competitors, not because their costs are lower, but because they do not know how much it costs them to produce goods. It is well, therefore, in connection with all purchases to bear in mind the fact that "bargains" are not always what they seem.

Some purchasers are bold enough to advocate selling on quality regardless of price; but few are so favorably situated as to be able to practice it. However, as has been pointed out before, if it were applied in connection with installment selling, better equipment would less likely be penalized because of price.

The purchase of equipment that embodies a background of development and manufacturer's prestige as well as superior workmanship will amply repay the buyer for the higher price he may have paid. Efficient and reliable work is an attribute of a good machine; one that may cost more in the beginning, but that will prove cheaper in the long run.

House Heating by Electricity

Although electricity is economically used for industrial and transportation purposes, the Fuel Board is of the opinion that, except in an auxiliary capacity, electricity for house heating is not practicable on a large scale under present conditions.

Extensive developments, however, may be anticipated in the utilization of the off-peak load for the generation of steam and its storage in accumulators for use as required during the 24 hours. Appreciable economies in the use of solid fuels are being effected by the use of electricity for cooking purposes and auxiliary heating. It has been computed that with anthracite at $17 a ton and electricity at 0.425c. a kw.-hr. the costs would balance without considering the saving of labor.—*From report of Dominion Fuel Board, Canada.*

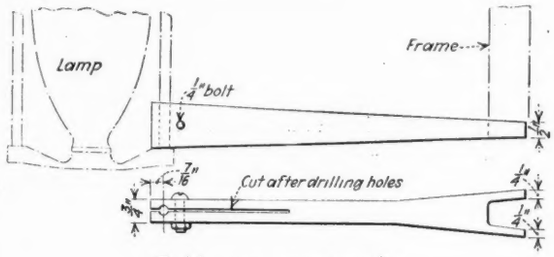
Right Out of the Plant

BOILED-DOWN EXPERIENCE PASSED ALONG TO THOSE WHO MUST SAVE MONEY, IMPROVE THE PRODUCT AND KEEP THE PLANT RUNNING

Guide Arm Improves Blueprint Machine

IN OUR blueprinting machine the lamp turned as it descended, and its side rods cast shadows on the tracings. These shadows caused white streaks on the finished blueprints. To overcome this difficulty I fitted a wooden arm to the lamp, as shown in the figure. This arm is guided by the machine's frame and prevents the lamp from turning.

The wooden arm is split to allow it being set over the lamp rod without disassembling. A one-quarter-inch



Guide-arm construction

bolt is used to tighten and hold the arm in place. The other end of the arm is cut out to suit the vertical wooden member of the frame of the blueprinting machine, which acts as a guide to prevent the lamp from turning. The up and down movement of the lamp is in no way hampered by the addition of the arm.

Worcester, Mass. DAVID FLIEGELMAN.

Low Pressure in Boiler Room Caused Combustion Trouble

A PROBLEM that caused an operating engineer, a coal company and a stoker salesman excessive loss of sleep recently came under my observation. Although the trouble was so simple that it was amusing, I think it was so unusual as to be interesting to combustion engineers.

The plant in question has two horizontal return-tubular boilers, each having 1,190 sq.ft. of heating surface. Only one boiler is used to carry the load, as at peak loads the rating that is carried does not exceed 125 per cent.

Last summer one of the boilers was equipped with an overfeed mechanical stoker, automatically controlled and operated with natural draft.

This stoker performed its work well and without any trouble until the beginning of cold weather, when the heating load was added. At this time it became difficult to carry the load, and clinker troubles developed to an excessive extent. As the weather grew colder, the clinker trouble increased and it became more difficult to carry the load. Finally it was necessary to put the spare boiler on the line in order to maintain steam pressure.

The engineer thought his troubles were due to a low-fusing-point ash, the coal company blamed the stoker, and the stoker salesman was "in bad" with all parties concerned. On investigation it was found that the rate of combustion on the stoker was from 14 to 16 lb. of coal per square foot of grate area per hour, and the available draft over the fire was 0.2 in. of water, which is admittedly sufficient draft for good combustion at this rate.

Finally, someone with a happy thought set up a portable draft gage outside the boiler room, bored a hole through the boiler-room door, and connected the draft gage with the inside of the boiler room. With all doors closed the gage showed a vacuum of 0.05 in. of water.

The low atmospheric pressure in the boiler room was equivalent to reducing the available draft above the fire bed, and the resulting lack of air was the only cause of our furnace trouble.

An open ventilator was found above the boilers that ran straight up to the roof. This ventilator acted in opposition to the stack and caused the vacuum in the boiler room. By opening windows and allowing a flow of air into the boiler-room, we entirely eliminated all stoker and clinker troubles. A. E. SMITH.

Boston, Mass.

Combination of Events Causes Fatal Accident

WHILE an obsolete disconnect switch was being replaced an unforeseen condition arose, which resulted in a lineman being killed. The switch was mounted directly outside a distributing station and was

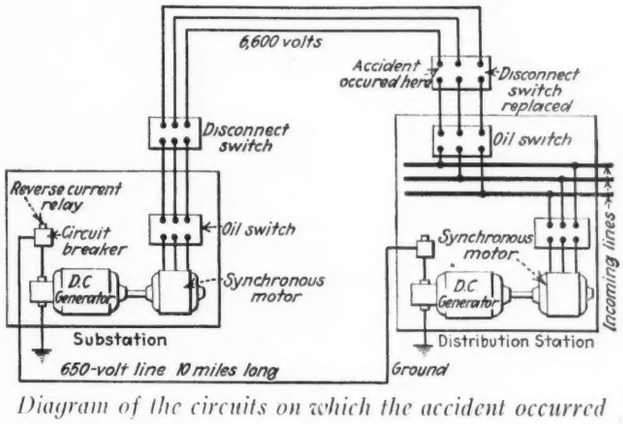


Diagram of the circuits on which the accident occurred

connected to a 6,600-volt circuit extending about ten miles to a substation supplying direct current to a line running between the two stations, as indicated in the figure. Arrangements had been made to supply the entire direct-current load from the motor-generator at the distributing station, to allow shutting down the substation and making the line dead while the switch was being changed.

Preparatory to the work, the oil switch was opened and locked. After a wait of a few minutes, the line foreman was notified that the power was off. The disconnect switch was opened and a lineman climbed the pole to cut the wires loose. When he cut into the wire, he was seen to stiffen and lunge forward in his safety belt. Another workman climbed the pole and with a hand ax cut the wires, but not before the first man was fatally burned.

A call to the other station elicited the information that the power was off and the operator was wiping the motor-generator. Testing the wires, the lineman found them dead, as they should be, and the switch was replaced by a new one.

Some time later it was found that the substation operator had stepped outside for a few minutes at the time the interruption was due. He had depended on a signal bell connected to a no-voltage release on the 6,600-volt switch to indicate when the power was off. Owing to a peculiar combination of events, the power did not go off until the operator came back inside the station and tripped the switches.

A street car was making a heavy pull at the time the oil switch was opened at the distribution station. The load made the voltage so low at the substation that the generator reversed without taking sufficient current to trip its circuit breaker. This allowed current at nearly 6,600 volts to be fed into the supposedly dead line. The reverse-current relay of the direct-current breaker was also found to be inoperative.

Of course the lineman should have grounded the line properly before beginning work on it, and they should have called the other station as a check. The facts remained that, (1) the reverse-current relay failed, (2) the generator did not take sufficient current to trip the breaker, and (3) the operator was absent at the time the generator reversed, and so failed to note the disturbance. In my opinion, had any one of these three events failed to happen, the accident would not have occurred.

M. A. ANDERSON.

Pittsburgh, Pa.

Ground Clamp Overheated

THE single-conductor lead-covered cables leading from a 10,000-kva. alternator to its oil switch had their sheaths grounded. The connections to the ground cable were made by two-piece iron clamps bolted to the lead sheath. Shortly after the generator went into service, the ground-clamp temperature was discovered to be dangerously high. This was due to the large eddy currents induced in the clamps by the heavy magnetic field set up in the iron around the cable. Making one-half of each clamp of brass and using brass bolts instead of iron corrected the trouble.

Trouble of this kind is not uncommon with alternating current. Single conductors must not be inclosed in iron conduit. All the phase leads should be in one conduit so that the magnetic fields of the different conductors neutralize one another. There will then be no trouble due to eddy currents unless a fault occurs on one phase, which upsets the electrical balance between the phases. The out-of-balance current will tend to produce eddy current in the iron conduit.

In some makes of switchgear the castings connecting the conductor sheaths to the switch are in halves, one being made of iron, the other of brass or aluminum. This prevents heavy eddy currents being induced in the casting. When searching for trouble on alternating-current systems, the possibility of eddy currents should not be overlooked, and iron parts surrounding conductors should be watched for heating.

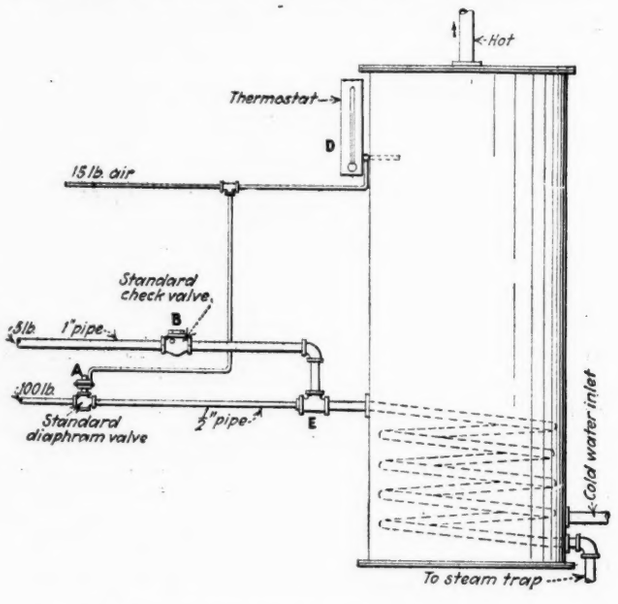
W. E. WARNER.

Brentford, England.

Use of Live Steam for Hot-Water Heating Reduced

IN ORDER to save some of our excess exhaust steam that goes to waste during the fall and spring period, we made the following improvement to the hot-water-supply tank. This tank supplies hot water to two domestic-science rooms, shower baths and several other outlets scattered throughout the school building.

Previously, the water was heated only with steam at 100 lb. pressure. The large demand for hot water and the size of the coils made it impossible to use low-pressure steam only; but by arranging the piping as illustrated, we were able to use some exhaust steam and to decrease the use of live steam.



Connections permit use of high- and low-pressure steam

We tapped the 10-in. low-pressure line and ran a 1¼-in. pipe to the tank, where we reduced it to 1-in. The ½-in. high-pressure steam line was cut at *E*, where we installed a ½x1x1-in. tee. A check valve was placed at *C* and the thermostatically controlled diaphragm valve was left at *A*.

When the temperature of the water rises to 180 deg., the thermostat *D* closes the diaphragm valve, thereby shrutting off the high-pressure steam. This allows the check valve *B* to open and low-pressure steam to flow into the heating coil. The low-pressure steam keeps the water at 180 deg. until a heavy demand for hot water lowers the temperature. The thermostat will then open the diaphragm valve, admitting high-pressure steam to the heating coils and automatically closing the check valve *B*.

We were somewhat surprised to find how seldom live steam was required in the coils.

NELS HILSEN.

Duluth, Minn.

As the Other Fellow Sees It

WHERE THE MAN WHO AGREES OR DISAGREES WITH AUTHORS OR EDITORS HAS A CHANCE TO SPEAK UP

Turbines in Spandau Station

I HAVE just noticed that in my article on the "Power Situation in Europe," in the Jan. 1 number, I credited the turbines in the new Spandau station in Berlin to the A.E.G. This was a mistake, and the final arrangement is six main turbines of 34,000 kw. each and two house turbines of 12,000 kw. each, all built by the Siemens Schuckert Werke. The steam conditions at the turbine throttle are 355.5 lb. per sq.in. and 743 deg. F., total temperature.

GEO. A. ORROK,
Consulting Engineer.

New York City.

* * * *

Why Scrape a Bearing to Fit?

RECENT articles appearing in *Power* on the babbitting of bearings bring to mind numerous experiences I have had in this field. My position, in comparison to the other authors, is a middle one—agreeing with both sides on certain points and disagreeing on others.

As I view the question, it is first necessary to take into consideration conditions under which the bearing operates. Certainly, a precision machine, such as a lathe or milling machine, will require a more accurately fitted bearing than a rock crusher or coal barrow, although these are less troublesome if properly adjusted.

There are cases where a bearing may be cast with both the mounting and shaft cold without requiring subsequent scraping. Such cases are few and far between and consist mainly of bearings working where large quantities of dirt and grit find their way to the working surface. The life of such bearings is short, but I have seen cases where a well-fitted and scraped bearing would last only a day or two longer than one installed otherwise.

In between the roughest made and the most accurately made bearings, there are an infinite number of shades of refinement with which the average engineer has to contend.

My most successful method, where ordinary conditions such as engine bearings, connecting-rod bearings and lineshaft bearings exist, is to prepare bearing support and shaft as outlined in "The Keys to Good Babbitt Bearings," an article published in *Power*. However, I vary the process slightly by wrapping the shaft with smooth tissue paper pasted on in such a manner that nowhere is it more than one layer thick. Be sure the paste is dry before casting the babbitt. It will be, if preheat is used. This is best accomplished by wrapping the shaft spirally. The paper saves a surprising amount of scraping by providing clearance where otherwise scraping would be necessary. When preheating a shaft wrapped with paper, do not allow the flame to play directly on the paper, for it will check.

I then fit both halves by scraping so that the shaft bears on approximately one-third to one-half the area of both halves in the deepest portion.

Any new bearing requires close watching and plenty of oil or grease until a "running fit" is obtained.

I do not wish to convey the impression that the bearings of industry are too expensive; on the contrary many are not expensive enough. Poor design, careless assembly or bad workmanship is likely to make a bearing expensive in the long run. However, there is plenty of room for improvement in reducing the cost and time of babbitting and rebabbitting common bearings.

In connection with the scrape or not to scrape policy I have observed bearings of high-speed machinery that showed only micrometric wear after a year's operation, the scraping and machinery marks being plainly visible. I have seen the same conditions on slide valves, connecting-rod guides and slippers in cast iron after several years' use. However, these were exceptionally well cared for.

There is one correct way, several good ways and many bad ways of doing a piece of work. The engineer's duty is to find the one correct way or the best of the good ways for the operation at hand.

KENNETH R. GIDDINGS.

Billings, Mont.

* * * *

The Diesel Engine for Small Plants

THE Jan. 1 issue carries an article by Robert M. Davis, calling attention to the fact that about 75 per cent of the power-driven machinery in American mills and factories is now driven by electric motors, and that about two-thirds of these motors are supplied with purchased electricity.

In commenting on the statistics, Mr. Davis made the following statement, to which I take exception: "There is a destined place for the private plant, but its expansion is limited to the larger mills and factories." The implication that there is little scope for the small industrial power plant is certainly not true wherever Diesel engine power is applicable. In fact, the Diesel engine has been found to be particularly adapted to the small private plant because it enjoys high efficiency even in small sizes. It should not be confused with the small steam plant, which burns much more coal per horsepower-hour than a larger plant, and whose power is therefore more expensive than central-station current unless there be a large and continuous demand for steam heat obtainable from the low-pressure side of the steam equipment.

The small Diesel engine plant, on the contrary, is not handicapped by low efficiency. There is not 10 per cent difference between the fuel economy of a Diesel engine of 150 hp. and one of 15,000 hp. Furthermore, the Diesel engine lends itself admirably to automatic control, so that a small plant can be capably operated with only the part-time attendance of one man.

The numerous Diesel power plants in service and under construction in moderate-sized industrial establishments right in New York City, close to modern superpower central stations, bear witness to the fact that the field for expansion of the Diesel-engined private plant lies as much in the small sizes as in the big.

EDGAR J. KATES,
Consulting Engineer.

New York City.

What's New in Plant Equipment

HOW THE MANUFACTURER CONTRIBUTES TO THE JOB OF GENERATING TRANSMITTING AND APPLYING THE POWER SERVICES

Improved Register-Indicator Recorder

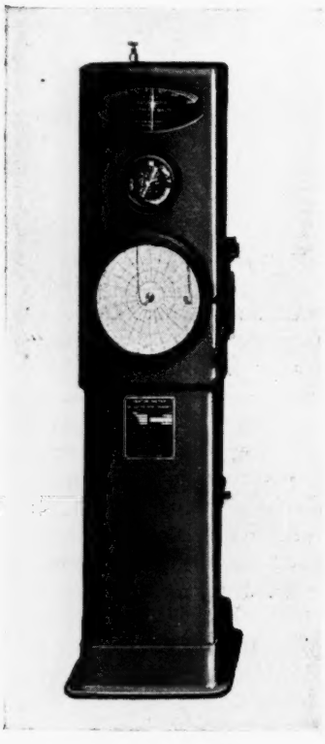
THE Builders Iron Foundry, Providence, R. I., has recently added to its line of meters the type Y register-indicator-recorder illustrated. The meter is designed for use with standard Venturi meter tubes, nozzles, orifices or other primary devices.

Although similar in several respects to the type M meter made by this company, the type Y is smaller in over-all size and the recording and indicating mechanism has been changed somewhat and arranged differently in this case.

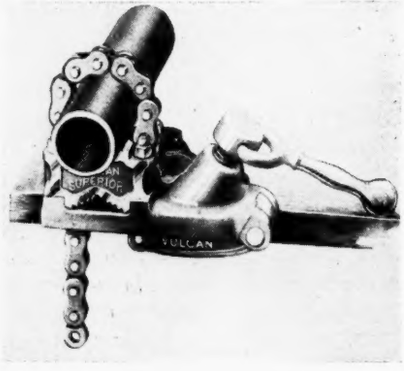
In the indicating mechanism, which is placed at the top of the instrument, the hand travels along the arc of a circle about 8½ in. in length. The graduations are practically uniformly spaced and show the rate of flow in gallons per minute or per day, cubic feet per second, pounds per hour, etc., as desired. The integrator, or counter dial, is placed directly below the indicator. From these dials the total flow can be read. The four small dial hands and the one large hand move in a clockwise direction, the large hand traveling around in a circle graduated in one hundred divisions. This integrating mechanism has been specially designed to assure easy recording of the counter totals. The recording mechanism takes a chart ten inches in diameter.

When used with a Venturi meter tube or nozzle, the mercury wells are designed for a maximum differential of 22½ in. of mercury, and when used with an orifice, for a maximum differential of either 60 or 120 in. of water (4.76 or 9.55 in. of mercury). For use with orifices a decimally graduated indicator dial and chart is provided.

The interior parts of the register are of corrosion-resisting metal such as bronze, stainless steel and Monel metal.



Type Y register-indicator recorder



Improved "Vulcan" pipe vise

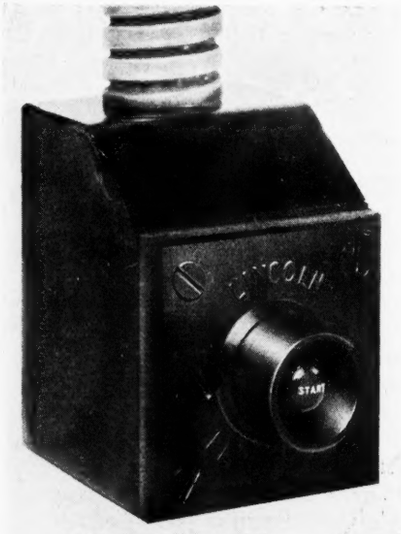
Improved Pipe Vise

IN THE improved "Vulcan" chain pipe vise illustrated, the handle is placed on top, where it is easy to operate, and the jaws are readily reversible. The principal parts are made of wrought steel, and the chain is the same as that used in the Vulcan chain pipe tongs.

The vise is finished with rustproof chromium plating and is furnished in two sizes for ⅛- to 2½- and ¼- to 4½-in. pipe respectively. It is manufactured by J. H. Williams & Company, Buffalo, N. Y.

Start Button Contained in Stop Button

A NEW safety-type push button, recently developed by the Lincoln Research Laboratories, is being marketed by the Lincoln Electric Company, Cleveland, Ohio. The design of this push button is a departure from the usual type. A ball-top start button is contained inside a large stop button which projects over the former. Thus the stop button protects the start button from accidental contact. The start button can be operated only by inserting a finger inside the stop button. The push buttons are colored in accordance with the accepted standard signal colors for control. The start button is of vivid green molded Bakelite with the word START in white letters across its ball-top face. The surrounding stop button is of brilliant red molded Bakelite.



Conduit enters the top of the push-button case

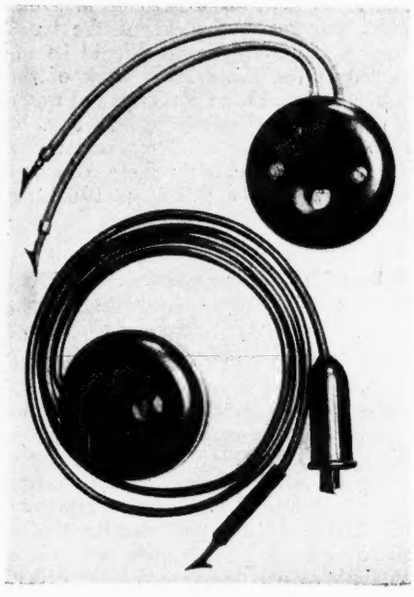
An arc-welded steel box incloses the switch mechanism. By removing four screws the entire operating mechanism may be taken from the box for wiring. The binding posts are plainly indicated by white letters on the molded Bakelite, thus reducing the chance of error in making connections. In the top of the steel

case an opening permits entrance of conduit inclosed wire to the button.

This push button was designed primarily for Lincoln induction starters, but is available and suitable for use with any type of push-button starter.

Watchcase Size Fuse Tester

The fuse tester illustrated, known as the Johnson, is designed to eliminate the hazards and uncertainties connected with the usual methods of locating blown fuses, dead sockets, short circuits and grounds. It consists of a resister coil and other parts inclosed in a heat resistant and nonconducting circular case, 2¼x1 in. in size. A 6.2-volt indicating lamp burns dimly at 100 volts and brightly at 250 volts. There are no movable parts. The tester may be had with



Johnson Fuse Tester

stiff 6-in. leads for general use, or with 18-in. flexible leads with an insulated clasp. It is manufactured by the Electric Tester Manufacturing Company, 346 Sherlock Bldg., Portland, Ore.

Portable Machine for Back-facing Boiler Handholes

THE illustrations show a portable machine for back-facing the insides of handholes in steam boilers. The machine consists essentially of a spindle for holding a cutter, incorporated in a cross-slide mounted on a base that can be clamped to the face of the boiler. The universal-joint drive makes it possible to use an electric or an air drill for power. Fig. 2 shows the machine in position on a boiler front.

A ratchet feed provides for longitudinal travel of the cross-slide on the base. The transverse travel of the cross-slide is universal. This combination of movements makes it possible to bring the spindle in position above the handhole after the machine has been clamped to the boiler. The spindle with cutter attached can then be lowered into the hole by the nut

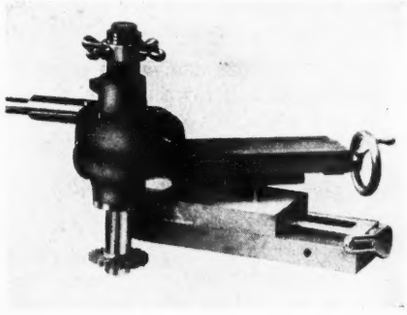


Fig. 1—Assembly of back-facing machine

feed. The nut feed also makes it possible to bring the cutter quickly into contact with the work. A hardened collar next to the cutter and larger in diameter than the spindle bears against the rim of the hole and protects the spindle from damage.

The spindle of the machine is made from special alloy steel, and the thrust is taken by a ball bearing at the top of the feed nut. The clamping nut for locking the spindle is integral with the housing. By loosening four nuts, the worm housing can be adjusted to four different positions to accommodate the driveshaft from four different angles. This adjustment allows the drill that supplies the power to be placed in the most convenient position on the job.

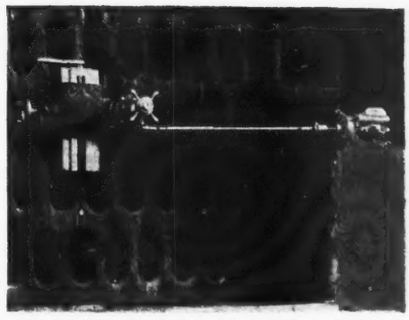


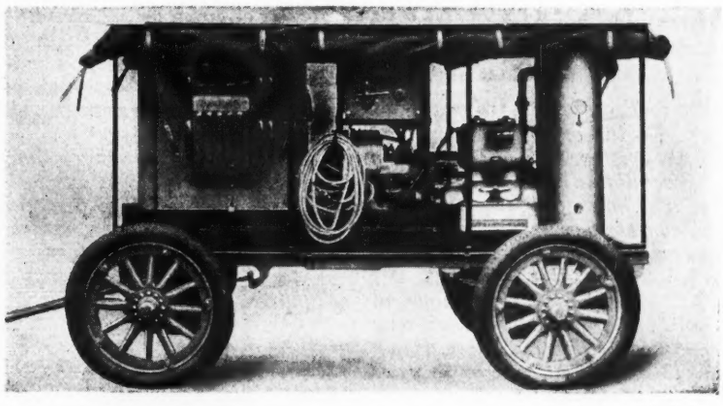
Fig. 2—Machine in position on boiler front

The machine can also be made without the worm drive in order to be used under the spindle of a drill press. It is put out by the Davenport Manufacturing Company, Meadville, Pa.

Gas Engine-Driven Welder and Air Compressor Unit

THE combined electric welder and air compressor unit illustrated is especially adapted to work where riveting, chipping and grinding are required in addition to welding.

Motor and welding generator are mounted on the forward part of the truck with a two-cylinder air compressor and receiver mounted at the rear. Provision is made for disconnecting the compressor when only welding is being done. The unit is fitted with fabric curtains which can be rolled up when the machine is in use and fastened down securely to protect it from the weather. The unit, which was recently put out by the Wilson Welder & Metals Company, Inc., Hoboken, N. J., is suspended on springs and pneumatic tires are provided on the wheels, making the unit suitable for hauling behind a truck.



Engine-driven welder and two-cylinder air compressor

FROM AMONG THE READERS'

Conducted
By
L. H. Morrison

Defrosting Brine Cooling Coils.—*We find that the process of deosting brine coils by scraping is slow and expensive. Is there a better method?* C.F.M.

If brine at atmospheric temperature is circulated through the coils, the frost will drop off before the room shows any appreciable temperature increase. A separate stock of brine can be held in a tank at atmospheric temperature and pumped through the coils by making suitable connections.

Engine Efficiency.—*I have noticed in various publications references to the engine efficiency of a steam engine. What is the meaning of this term?* J.M.C.

Engine efficiency is the ratio of the heat converted into work in the actual engine to the heat available for conversion, or is the ratio of the actual work done by the engine to the work that could be done by a perfect engine working between the same limits when operating on the same cycle.

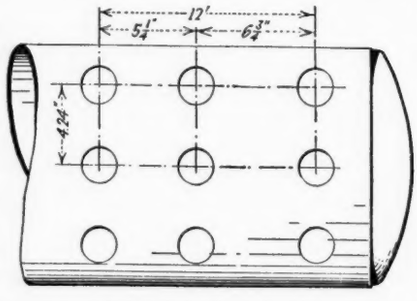
Best Cooling Tower.—*We must install a cooling tower for a Diesel plant, but find the bids vary from $500 to $2,000. What is the yardstick to use in measuring these bids?* L.A.T.

Material and workmanship are of course important factors. From an operating standpoint you are mainly interested in the lowering of the water temperature by the tower from a given inlet temperature, with the atmospheric air at given conditions of temperature and humidity.

Amount of Ligament Between Tube Holes.—*An argument came up where I am employed when I wanted to place 3¼-in. diameter tubes, with 3 29/32 diameter tube holes, at 9 deg. centers in the roundabout in a 54-in. diameter drum. The tubes were spaced at 5¼ and 6¾ in. on the longitudinal line, giving a unit pitch of 12 in. The layout is shown in the illustration. The other engineer's method was as follows: First deduct from the 12-in. unit pitch two tube holes of 3 29/32 in. each, which leaves 5.4375 in. of metal. This divided by two gives 2.718 in., which he calls the average metal between two tube holes. Then one-half of 2.718 in., or 1.359 in., he claims, is the amount of metal that must be between two tube holes in the roundabout. But I say this gives more than one-half the strength, because with the tubes spaced 5¼ and 6¾ in. the average is high and does not give the true strength.* J.M.L.

The proper method of figuring the ligaments is first to take the line of tubes that is parallel to the axis of the shell. The efficiency of the ligaments in case of unequally spaced tubes is $E = \frac{P - nd}{P}$, when P is unit length of ligament, n the number of tubes in length P, and d is the diameter of tube holes. In your case, $P = 12$ in., $d = 3\frac{29}{32} = 3.28$ and $n = 2$. Therefore, $E = \frac{12 - (2 \times 3.28)}{12} = 45.3$ per cent.

The A.S.M.E. Boiler Code states that "The strength of these ligaments between the tube holes subject to a longitudinal stress shall be at least one-half the required strength of those ligaments between the tube holes which are subject to a circumferential stress."



Proposed tube layout

Consequently, the strength of the roundabout ligaments should be at least one-half that of the longitudinal ligaments. If the strength is one-half, the efficiency is one-half.

To find the closest centers, the roundabout efficiency is taken as one-half of the longitudinal, or 22.65 per cent. Setting this in the equation, $E = \frac{P - d}{P}$, to find P, we have $0.2265 = \frac{P - 3.28}{P}$, or $P = 4.24$.

The circumference of a 54-in. drum is $54 \times 3.1416 = 169.64$ in. Then in degrees the pitch may be found by the ratio $\frac{\text{deg. pitch}}{360} = \frac{4.24}{169.64}$, or deg. of pitch = 9 deg., which agrees with your contention. In other words, the value of 9 deg. is practically the minimum one.

The method of the other parties recommended does not follow the code, as one cannot use *averages* where the spacings are unequal, if the minimum ligament is desired.

Factor of Evaporation When Generating Superheated Steam.—*What is the factor of evaporation when a boiler generates steam at 200 lb. gage with 100 deg. superheat from feed water at 212 deg. F.?* C. R. T.

A gage pressure of 200 lb. is equal to 214.7 lb. per sq.in. absolute, and according to the steam tables, a pound of steam at that pressure, superheated 100 deg. F., contains 1,259 B.t.u. measured from feed water at 32 deg. F. There has been added to each pound of feed water 180 B.t.u. to raise its temperature from 32 to 212 deg. F. and each pound of feed water at 212 deg. has received 1,259 — 180 = 1,079 B.t.u. during conversion into steam of the stated pressure and quality. Unless otherwise provided, a combined boiler and superheater should be treated as one unit, and the equivalent of the work done by the superheater should be included in the evaporation work of the boiler. Evaporation of a pound of water at 212 deg. into steam at 212 deg. F. requires 970.4 B.t.u. Therefore, under the actual conditions the factor of evaporation would be 1,079 ÷ 970.4 = 1.111.

The Highest Steam Pressure Possible.—*What is the highest steam pressure possible? How and when does the latent heat become nil, and what happens?* G.A.M.

There is no limit to the pressure obtainable with steam any more than with any other substance. If you compress it hard enough, the pressure will run up. Professor Bridgeman, at Harvard University, has obtained pressures of a quarter of a million pounds per square inch. Whether there could be anything that we call steam in such a high range is a matter of speculation; probably it should be called a gas.

What you probably intended to refer to is the critical pressure, which is about 3,200 lb. per sq.in., with a corresponding temperature of somewhere near 700 deg. F. At this point the latent heat is zero.

Conditions in the neighborhood of the critical point are discussed in many textbooks on thermodynamics, and the subject cannot be adequately treated within the limitation of available space. Briefly, as water is heated toward the critical temperature, under sufficient pressure to keep it liquid, its density gradually decreases, because it expands with rising temperature. Ultimately, a point is reached where the whole mass has the same density as the steam above the water and one might say it is all steam or all water.

The Benson boiler operates at the critical pressure, the advantage being that no steam-liberating drums are needed.

PROBLEMS

ANSWERS

from Our Readers

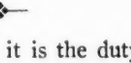
THE QUESTION

IF AN operating engineer has an idea the adoption of which would apparently save his employer thousands of dollars and the chief engineer refuses to consider it, is the operator justified in going over the chief's head directly to the general manager?

A. L. W.

I THINK the operator would be justified in going over the chief engineer, but he should do it in a manner both open and fair. He should explain to the chief engineer that if the latter refused to consider the idea or present it to the general manager, the operator would present it himself.

R. J. DONOVAN.
East Bound Brook, N. J.



I CONTEND that it is the duty of an operating engineer to report his idea to the manager. But the engineer should be practically sure that the idea would accomplish a saving.

It is his duty first to call the chief engineer's attention to his idea or change, explaining it in detail. If the chief refuses to give a good reason for not adopting the idea, the operator should examine the proposition again, making sure of every detail.

Then go over the chief's head. Most general managers are diplomatic and will handle the idea so that no friction will exist between the operator and chief engineer.

C. D. DONAVAN.
Elephant Butte, N. M.

GOING over one's superior's head is a breach of discipline and the superior has the right to impose a penalty for the infraction. I think that the man should be dismissed.

In one plant I was quite intimate with the manager. But in answer to my inquiry he stated that he would entertain suggestions only with the chief's approval on them. This of course made me feel secure in the event that any of my subordinates were to approach the chief. My opinion is that any idea should be carried to the manager through the proper channels.

HARRY P. ROBBINS.
Washington, D. C.

I CERTAINLY believe an operator should go over his chief's head at such a time. A man so narrow that he does not encourage suggestions for betterments, should not be a chief engineer.

Then there is the question of loyalty to the manager, who really is responsible for the pay check. If you can make a man feel that he is working in "his" plant and that anything he may do to better the operation will be appreciated, you go a long way toward making him really valuable.

EDWIN M. MALONEY,
Supt. of Water & Light Dept.
Albion, Ind.

IN SOME plants the manager is not inclined to listen, as I found out when I offered what seemed to me to be a good thing. All I received was a curt instruction to take it up with the chief.

At another time I was after the chief to install some piping that would save us from shutting down about once a week. After the pipe had been installed, the manager remarked upon the fine idea the chief had for preventing shutdowns. That discouraged me for a while.

I believe that if the manager comes to the power house and talks to the engineers it would be quite safe to give a strong hint about the idea and see how he responded. Say that you were talking the idea over with the chief, and display surprise that the manager had not heard of it.

But before going to the office when the chief is not around, a fellow ought to know where he can get another job.

ALBERT HESS.
Newark, N. J.

MOST assuredly he is justified in carrying the idea to the general manager, but he had better be sure his idea is right. Often some junior engineer has an idea that he thinks would entirely revolutionize the whole plant and in some cases defy the laws of gravitation. When the chief points out that he is wrong, he gets an idea that the chief is old fashioned. He goes "over his head" to the general manager, who in the majority of cases is wise enough to know that the scheme will not work and sends the engineer back to the chief.

We have some chiefs that have stood still for twenty years, and are holding their jobs only because the managers have forgotten them. This class will oppose anything under the sun and will never give credit to a subordinate for a new idea. With this type of chief the operator is justified in taking his plan to someone that is broad-minded enough to see the point. But when he does this he is treading on thin ice, for if the news gets back to the chief he will have a hard road to travel. But if he is right, he has no reason to fear anyone.

THOS. M. STREET.
Wilkesbarre, Pa.

MY ANSWER is that, theoretically and morally, the engineer is justified in going to the manager, but from a practical point of view he should never do so.

The chief engineer is the general manager's right-hand man, placed there for his capability, knowledge, foresight and other qualities. He has the general manager's confidence or he would not be on that job. The operating engineer has his job on account of, perhaps, his youth and inexperience.

Why should he expect the general manager to gather up all the ideas of every operating engineer in the plant, without consulting the chief engineer?

What effect would such a transaction have upon the morale of the chief engineer, who could only have contempt for both the manager and the operator?

The operating engineer should sell the idea to the chief engineer. His success in life may hang on salesmanship, and he should find the key to the chief engineer's sympathy.

L. G. JONES.
Dayton, Ohio.

A Question For Our Readers

WHEN a safety valve opens, the water immediately below it lifts up with a geyser effect. What causes this?

P. S.B.

Suitable answers from readers will be paid for and published in the March 5 issue.

Operator's Problems Stressed at A.I.E.E. Convention

NINE technical sessions at which 42 papers were presented featured the Winter Convention of the American Institute of Electrical Engineers, held in the Engineering Societies Building, New York City, Jan. 28 to Feb. 1. During the week members and their guests were given opportunity to visit power and other plants in New York City and environs. A smoker on Tuesday night in the auditorium of the Engineering Societies Building and a dinner dance on Thursday evening at the Hotel Astor comprised the chief entertainment.

At this convention an unusually large number of the papers presented were of direct interest to operating men. Three of them were on a new type of high-voltage circuit breaker that interrupts the arc in a deionization chamber. This equipment is known as a deion circuit breaker. The theory of this circuit breaker was explained by Joseph Slepian, and its development and construction for circuits up to 15,000 volts were discussed by C. R. Dickinson and B. P. Baker. B. G. Jamieson told of field tests made on circuit breakers of the deion type on the Commonwealth Edison Company's system.

Deion Circuit Breaker

In this type of circuit breaker the arc is drawn in air and forced into a deionizing chamber, where it is broken up into a multiplicity of short arcs, which are moved over metal plates at a velocity sufficient to prevent burning. This movement of the arc is maintained around an annular path until the current wave reaches zero, after which the arc stream is deionized, quickly changing from a good conductor to a good insulator.

The deionizing chamber consists of a stack of thin copper plates, spaced a short distance apart to form a series of gaps, which inclose the arc runways. These gaps are divided into groups and separated by coils connected in such a way that the magnetic fields of adjacent coils are in opposition, which causes the fields to force the arc in between the plates, where it is quenched.

On the system of the Commonwealth Edison Company, 82 tests have been made on two of these breakers, designed for 2,000 amperes at 15,000 volts. Currents as high as 35,000 amperes have been ruptured successfully. Of 82 operations, only two failed to clear the circuit. These two failures are particularly interesting compared to those of oil-switches. In neither one of these cases was there any damage to the testhouse or other equipment in the test circuit. There was no resultant fire, and owing to the absence of oil throwing, the work of preparing for succeeding tests was much expedited. These tests were made on group-phase and isolated-phase units. On the final day of the isolated-phase unit tests, fifteen three-phase operations, with current varying from 12,600 to 22,400 amperes, were made in two hours and forty minutes.

Some of those discussing these papers emphasized the advantage of this type of breaker, over the oil type. These advantages include the elimination of oil handling and the fire and explosive hazard due to the presence of oil; a decrease in the hazard to life and property; a decrease in inspection and maintenance costs; the high speed of operation should have a beneficial effect on system stability and increase the reliability of service.

Although considerable stress was laid on the fire and explosion hazards connected with oil circuit breakers, it was also pointed out that with modern oil circuit-breaker installations these hazards have been practically eliminated.

Attention was called to another type of air-break circuit breaker that has ruptured 35,000 amperes at 12,000 volts.

Deion circuit breakers are in active use on 2,500 volts, and units are under construction for regular operation on a 12,000-volt system. Experimental work is being conducted on a design of this type of breaker for 25,000 volts. The prediction was made that it may be possible to develop breakers of this type for the highest commercial voltages.

"Automatic Reclosing High-Speed Circuit Breaker for D.C. Railway Equipment" was the subject of a paper by A. E. Anderson. These breakers will open in about one-twelfth of the time required by the ordinary mechanically latched air circuit breaker having carbon tips. One of these new circuit breakers has successfully interrupted 61,500 amperes at 600 volts.

In a paper on "Line-Start Induction Motors," C. J. Koch arrived at the following conclusions:

1. The field for the line-start general-purpose induction motor is large and is steadily expanding.

2. The line-start motor has necessarily a lower maximum running torque than the standard squirrel-cage motor, the maximum torque being roughly inversely proportional to the starting current.

3. Because of this lower maximum torque it is not advisable to build line-start motors for general purpose use with a starting current below the equivalent of six amperes per horsepower on 440-volt 60-cycle circuits.

4. Motors in sizes above 30 hp., built to meet the N.E.L.A. rules, are not suitable for general-purpose applications owing to the low maximum running torque which they develop.

5. Two classes of line-start motors are available, normal-torque and high-torque motors. The normal-torque motor is for general-purpose applications. The high-torque motor is intended for a special type of service and its use involves a sacrifice in running characteristics.

6. From the design point of view there are two types of line-start motors, high-reactance and high-resistance. As a whole the characteristics of the high-reactance type are superior.

7. The running characteristics of normal-torque line-start motors compare favorably with those of standard squirrel-cage motors.

CONSTRUCTION and tests of 15,000-volt heavy-duty oil-less circuit breakers; automatic reclosing high-speed direct; current circuit breakers; line-start induction motors; insulation tests of electrical machines before and after placing in service, and influence of temperature on large commutators are some of the subjects that were discussed.

8. Special care is needed in preparing guarantees for line-start high-reactance motors from no-load test data owing to the change in leakage reactance with speed.

9. Starting-current values should be measured at full voltage rather than increased proportionally from readings taken at reduced voltage.

Tests on Used Machines

The A.I.E.E. Standards provide high-potential values as a basis of design and construction of insulation for electric machines. These standards apply to factory tests on new machines. There is also a need for high-potential test standards for machines before and after they go into service. C. M. Gilt and B. L. Barns presented a paper on "Insulation Tests of Electric Machinery Before and After Being Placed in Service," in which they discussed, first, high-potential tests on new equipment before being placed in service and, second, tests as an occasional check on equipment that is or has been in service.

The authors expressed the opinion that since it is desirable not to cause deterioration of the insulation by the test procedure and that the equipment may have been subject to some slight deterioration in handling and may have absorbed a small amount of moisture, and that factory tests have already been made to insure against inherent defects in the insulation, it would seem reasonable that the test before operation should be somewhat less severe than that made at the factory.

Test Voltage Values

It was pointed out that a number of arguments have been advanced for a reduction of 25 per cent of the original test voltage, while some believe that the reduction should not be more than 15 per cent to correspond with the existing standards for the test voltage of assembled equipment. Still other arguments are advanced for maintaining the magnitude of the original factory test voltage, but reducing the time of test from one minute to an instant. The British standards recognize the establishment of such a test voltage for this purpose and have set it at 25 per cent below the factory value.

It was suggested by the authors that for the same reason that it is desirable to set up a standard practice for testing the insulation of electrical apparatus at the time of initial installation, it is also desirable to establish a rule or recommendation as to what tests would be suitable for a maintenance program.

As a basis for consideration and possible acceptance by the Institute, the authors made recommendations, which in brief are:

For initial operation—a voltage 85 per cent of factory test for one minute, based on connected equipment receiving the lowest factory test, and

For maintenance—a test to ground of 125 per cent rated voltage plus 500; and between phases, 175 per cent plus 500 volts—supplemented by periodic measurements of insulation resistance.

F. T. Hague and G. W. Penney in their paper, "Influence of Temperature on Large Commutator Operation," set forth information of general interest to operating engineers, obtained by experimental work on large commutators. It was pointed out that many cases of blackened and burned bars are caused initially by a slight roughness that causes irregular commutation and a slight sparking, which, when once started, gradually becomes worse. A radial variation of one ten-thousandth of an inch between adjacent bars may give serious trouble. Some causes of roughness were discussed, showing that temperature is a major factor, but redesigning the commutator to reduce the temperature does not necessarily cure the trouble and may actually give poorer performance.

The authors described some methods of commutator testing, among them one for testing roughness by measuring brush-contact-drop voltage.

Many Agencies Engaged in Fuel Research

By A. A. Potter

Dean of Engineering Schools and Director of the Engineering Experiment Station, Purdue University

THE National Coal Association, in a "World-Wide Picture of Bituminous Coal Research as of 1928," lists present research activities on fuel in the United States and abroad. Those of particular interest to the power industry include investigations dealing with the preparation, storage, combustion, gasification, carbonization and processing of coal.

Preparation and Storage

Coal-washing problems are being investigated by the Carnegie Institute of Technology at Pittsburgh, Pa. The United States Bureau of Mines is studying coal washing and briquetting at its Seattle, Wash., station; coal impurities at its Tuscaloosa, Ala., station; spontaneous combustion and coal storage at its Pittsburgh, Pa., station. The Department of Industrial and Scientific Research of England, under the direction of Dr. C. H. Lander, is investigating coal washing and cleaning, spontaneous combustion and briquetting. Several other agencies in England are studying preparation and storage of coal, including washing and spontaneous-combustion problems.

Combustion of Fuels

The Iowa State College at Ames is studying methods of burning low-grade Iowa coal. Johns Hopkins University is investigating boiler-heating surfaces for pulverized coal. Boiler refractories are being studied by the American Society of Mechanical Engineers in cooperation with the Bureau of Mines, Bureau of Standards and the National Electric Light Association. The Bureau of Mines is making investigations on furnace settings as affected by furnace conditions, heat flow through furnace walls and clinker formation in boiler furnaces. The Danish Fuel Control Union, of Copenhagen, Denmark, is studying heat losses in flue gases due to incomplete combustion. The Department of Industrial and Scientific Research of England is investigating smoke elimination, combustion of coke in boiler furnaces and CO_2 as well as CO recorders.

Gasification, Carbonization and Processing of Coal

The American Gas Association, of New York, is studying, in co-operation with the United States Bureau of Mines, gas- and coke-making properties of American coals. The Bureau of Mines is also investigating at its Pittsburgh, Pa., branch low-temperature carbonization of coal and byproduct yielding properties of American coals. At the Engineering Experiment Stations of the University of Illinois and of Ohio State University experiments on low-temperature carbonization of coal are being carried on. Old Ben Coal Corporation, of Chicago, Ill., is also investigating low-temperature carbonization methods. Carbonization and briquetting of lignite as well as peat fuel are being studied by the Department of Mines of Canada at Ottawa. In Germany, Austria and France much attention is being given to researches on low-temperature as well as high-temperature carbonization of coal, coal processing, utilization of coal byproducts, utilization of low-temperature tars, and hydrogenation of coal and semi-coke.

In general, European research organizations are definitely in the lead in coal-processing research. However, the several fuel conferences and the activities of engineering and scientific societies have stimulated fuel research in this country. The low cost of fuel in the United States and the poor market for coal byproducts justify the attitude of American industry toward low-temperature carbonization and much of other fuel research now carried on in Europe.

[*"Investigations in Power Engineering at the Engineering Colleges" will be discussed by Professor Potter in the March 5 issue.*—Editor.]

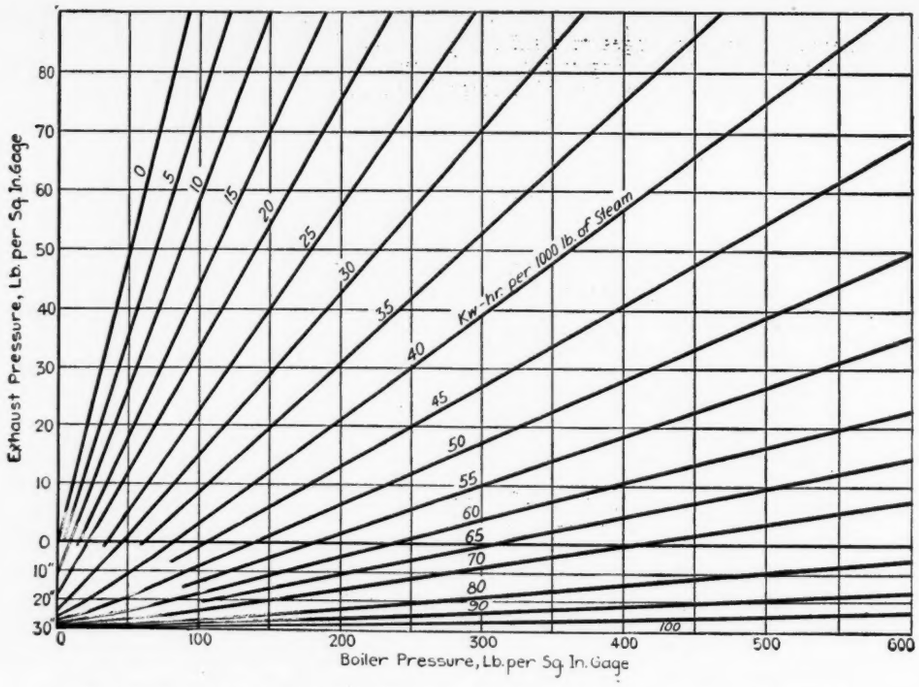


Fig. 1—Power developed by ideal engine using saturated steam at various pressures and exhausting at various pressures

BALANCING HEAT AND POWER

in Industrial Plants

By R. V. Kleinschmidt

Research Engineer,
Arthur D. Little, Inc.

The fullest possible utilization of byproduct power is one of the major power problems of American industry, one that ranks with the economical application of mechanical and electrical power and steam and the efficiency of boiler plants and prime movers. In this abstract of a paper presented before the annual meeting of the A.S.M.E., Dec. 3-7, 1928, Doctor Kleinschmidt outlines the fundamentals and shows how practical problems in the balancing of heat and power may be solved with the aid of convenient charts.

INDUSTRIAL plants use large amounts of heat in such processes as drying and evaporating, water heating, cooking and digesting, and in kilns, furnaces and ovens. Practically all plants in the Northern States have a substantial space-heating load during six months or more of the year. Moreover, all industrial plants have power and electric-lighting loads.

In plants like paper mills, textile finishing mills and chemical factories, where there is a substantial heating load, the possibility of generating power as a byproduct of the process steam presents an opportunity for possible economy. When all the power used in the plant is thus generated without rejection of heat in condenser water, the power and heat loads may be said to be balanced.

This paper discusses the most important factors that determine or affect this heat-power balance. These factors are:

1. Boiler steam pressure and superheat.
2. The pressures and temperatures required by the process.
3. Type and characteristics of power-generating equipment.
4. Utilization of waste heat.

Before discussing these factors in detail, it will be desirable to recall the fundamental laws of the interconversion of heat and power. These may be simply stated as follows:

1. Power can be completely converted into a definite amount of heat at any desired temperature. A kilowatt-hour of electric power is convertible into 3,412 B.t.u., whether in producing an electric arc or in melting ice.

2. Heat can never be completely converted into power. Only a definite maximum percentage is theoretically capable of conversion, and this only by a proper prime mover. The maximum percentage depends on (*a*) the temperature at which heat is supplied to the prime mover, and (*b*) the temperature at which the remaining heat can be rejected from the prime mover.

3. For every kilowatt-hour of power generated, a definite quantity of heat (3,412 B.t.u.) is actually used up and disappears as such.

4. The conversion of this portion of heat into power is accompanied by a definite drop in temperature of the remaining heat not so converted.

In more familiar terms the maximum theoretical power that can be developed by an engine per pound of steam handled depends fundamentally on the temperature of the steam entering and leaving the engine, and therefore on pressures and superheats. The portion

of this maximum theoretical power which the engine will actually deliver depends on how closely it follows the theoretical cycle and on mechanical loses.

Since the combustion of coal liberates heat at a temperature far above that required in most industrial processes, this heat can generate power before being used in process. The power so generated will be referred to in this discussion as "byproduct power." In the near future power-plant engineers will regard this byproduct power as too valuable to be neglected. In generating byproduct power, a pound of coal may easily yield one-half kilowatt-hour, worth at least one-half cent, and seven-eighths of the heating value remains for use in such processes as drying and water heating. The problem of balancing heat and power resolves itself into the problem of generating from the process heat the maximum byproduct power that can be economically used.

The Heat-Power Survey

The first step in attempting to balance the heat and power loads of an industrial plant should be a careful survey, involving accurate measurements, of the heat and power required by the various processes. In making this survey, careful attention should be paid to points where slight changes in operating procedure may make substantial improvement in the balance of heat and power. For this work intimate knowledge of the process concerned and co-operation with the plant superintendent are necessary.

While it is not usually regarded as within the province of power-plant engineers to consider changes in process, experience has shown that intelligent study of conditions frequently brings about changes that are desirable not only from the power standpoint, but from the point of view of decreased labor and improved product.

In one paperboard mill a rearrangement of the steam supply to the driers not only decreased the back pressure on the turbine from 40 lb. to 10 lb., but also increased the daily production beyond all previous records. The advantages of a survey, quite aside from any saving of fuel, are further illustrated by the case of a large Southern sawmill, where redistribution of steam saved a contemplated investment in additional boilers.

Heat-Power Ratio

In order to determine at the outset whether a balance of heat and power can probably be worked out, and along what lines, it is desirable to determine the over-all heat-power ratio for the plant. This ratio is the total process-heat requirement divided by the total power requirements, and is expressed in B.t.u. per kilowatt-hour. By comparing this ratio for a given plant with the values given in the accompanying table, the probability of a balance of heat and power will be readily determined.

The accurate determination of the necessary steam and power conditions to produce a proper balance can be greatly simplified by certain charts that have been used with success for this purpose by the author. The object of these charts is to show at a glance what steam conditions are necessary in order to get a given amount of power from a definite quantity of process steam. Fig. 1 shows one such chart which is very useful in considering the effect of decreasing exhaust pressure or increasing boiler pressure. This chart is based on an ideal engine, but it is a simple matter to allow for any actual efficiency with regard to the ideal Rankine engine.

The type of information that can be obtained from this chart can best be illustrated by an actual example. The present boiler plant of a paper mill operates with saturated steam at 160 lb. pressure. The plant uses 40,000 lb. of steam per hour at 30 lb. pressure in driers. It is necessary to generate 1,150 kw. from this process steam in order to balance the heat and power loads. By making certain changes in the paper machines, it will be possible to reduce the back pressure to 10 lb. in the driers.

The problem to be considered is: Are the changes in the paper machines justified, or shall a new high-pressure boiler plant be considered? By referring to Fig. 1, we see that 160-lb. steam in expanding to 30 lb. back pressure will theoretically generate 31 kw.-hr. per thousand pounds of steam. Assuming 67 per cent turbine efficiency the 40,000 lb. would generate 31 × 0.67 × 40, or 828 kw. The required 1,150 kw. represents 139 per cent of this 828 kw. power which is available under present conditions. Assuming the same turbine efficiency under higher boiler pressure or lower back pressure, we shall require theoretically 31 × 1.39, or 43 kw.-hr. per thousand pounds of steam.

From the chart we find that this can be obtained by raising the boiler pressure to 290 lb. with the present 30-lb. back pressure, or by reducing the back pressure to 10 lb. with the present 160-lb. boilers. A detailed consideration of costs showed the second to be the more desirable solution.

This illustration serves to bring out very clearly the great importance of keeping down back pressures, since a decrease in back pressure of 20 lb. (from 30 lb. to 10 lb.) was equivalent to raising the boiler pressure by 130 lb. (from 160 lb. to 290 lb.).

Although decreased back pressure is

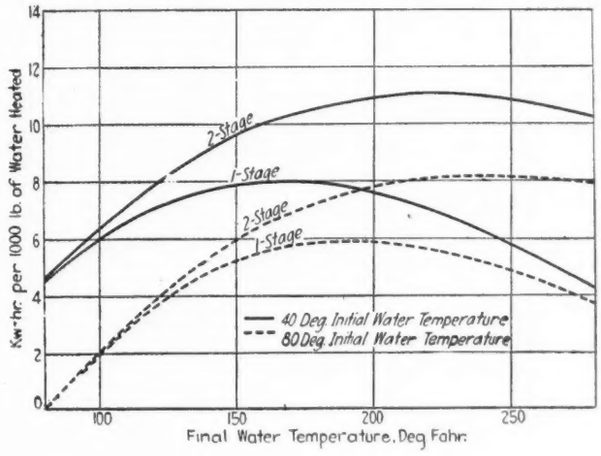


Fig. 3—Comparison of single-stage and two-stage water heating

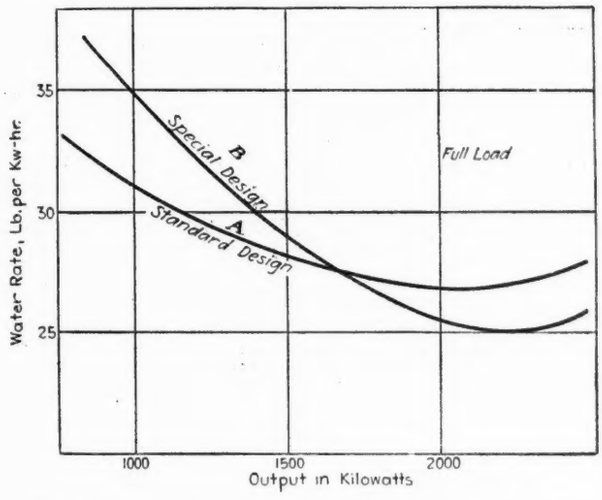


Fig. 2—Comparative water rates of standard and special turbines

TYPICAL HEAT-POWER RATIOS

Plant	Exhaust Temperature, Deg. F.	Heat-Power Ratio B.t.u. per Kw.-hr.
Non-condensing plant	212	30,000 up
High-pres. central station, condensing	80	15,000
Mercury-steam plant	80	10,000
Diesel-engine plant	700	10,000
Diesel-steam plant	80	8,000

usually the simplest method of increasing the power from process steam, it is frequently necessary to use high boiler pressure as well. It is possible to deduce from Fig. 1 the fact that the percentage increase of available power due to raising the boiler pressure a given amount is greater for high exhaust pressures than for condensing plants. For example, raising the boiler pressure from 200 to 400 lb. with 42 lb. back pressure will increase the theoretical power per thousand pounds of steam from 30 to 45 kw.-hr., an increase of 50 per cent, while at 26-in. vacuum the same increases in boiler pressure will raise the available energy from 90 to 102 kw.-hr., or an increase of only 13 per cent. The industrial plant that is using exhaust steam under pressure may well consider the advantages of boiler pressures as high as are used in the best condensing central-station plants.

One factor must be borne in mind in considering the effect of superheat on power developed by process steam. When saturated steam develops power in an engine of reasonable efficiency, a portion of it condenses into moisture which is ordinarily removed in a separator before the steam is used in process. In this way the dry steam sent to process is less than the steam supplied to the engine throttle by an amount which may easily be as high as 10 per cent. When any large amount of superheat is present in the throttle steam, a correspondingly smaller amount of steam is condensed, so that the dry exhaust steam will in this case usually be nearly equal to the steam supplied to the throttle. It follows that, although superheat decreases the steam supplied to the engine throttle, there is not a proportional decrease in the pounds of dry steam available for process use.

Although the effect of superheat in increasing the power developed from a given amount of steam is not large, the addition of superheaters is usually not a difficult problem in an existing boiler plant, and it frequently happens that the resulting economies are very substantial. Quite aside from any question of heat and power balances, superheat is always essential in high-pressure boiler installations in order to insure dry steam to as many as possible of the turbine stages. It is probable that the advantages of superheat even in low-pressure boiler plants have received far too little attention in the past.

Characteristics of Power-Generating Equipment

The theoretical curves given in Fig. 1 must, of course, be modified in any actual case by the efficiencies and characteristics of the equipment in which the steam is to be used. This subject is one that might well take up an entire paper and an extensive one at that. A brief résumé of the facts is, however, pertinent here.

The two main types of steam power-generating equipment — turbines and engines—have very different characteristics. The efficiencies of turbines do not vary greatly over various pressure ranges. There is some decrease in stage efficiency at very low pressures. But factors of equal or greater importance are the size of unit and the degree of efficiency that is justified in view of increased costs of high-efficiency designs. Turbines below 1,000 kw. decrease rapidly in efficiency with decreasing size. Such small turbines range from 40 to 65 per cent in efficiency. The sizes above 1,000 kw. range from 50 to 85 per cent in special cases. Special high-efficiency turbines are expensive, but are frequently justified in such plants as paper mills, where the loads are steady and continuous. Such mills occasionally operate with over-all annual load factors of over 75 per cent, and under such conditions specially designed turbines are in order.

Stock Turbines May Be Best

However, attention should be called to the fact that special high-efficiency turbines are normally designed for very closely limited conditions as to pressures, steam flows and power loads. If plant conditions are subject to considerable fluctuation, over-all efficiencies may not be improved by such design. Fig. 2 shows the water-rate curves for two turbines; *A*, a stock machine, and *B*, a special design. Machine *B* is essentially a base-load machine and as such gives high economy, but on fluctuating loads machine *A* is as good in over-all performance.

"In generating byproduct power a pound of coal may easily yield one-half kilowatt-hour, and seven-eighths of the heating value remains for use in such processes as drying and water heating. The problem of balancing heat and power resolves itself into the problem of generating from the process heat the maximum amount of by-product power that can be economically used."

The efficiencies of reciprocating engines vary much more than do those of turbines. The efficiencies in small sizes are noticeably higher than for small turbines when the engines are in good condition. Engines do not utilize low or very high pressures as well as turbines. The steam consumption of a reciprocating engine is not affected nearly so much by changes in back pressure as is that of a turbine. If a small amount of steam at high back pressure is needed, it can frequently be obtained from engines having throttling governors without a measurable increase in their steam consumption.

Internal-Combustion Engines

The maximum-efficiency point of an engine usually occurs between half and seven-eighths load, while for a turbine it is generally at or near full load.

A development which gives promise of materially widening the field of balanced heat and power loads in industrial plants is in connection with high-efficiency internal-combustion engines. The power developed per heat unit by such engines can, under proper conditions, exceed that of any of the other commercial types of power-generating equipment.

Hot water from the cylinder jackets of these engines, heated further, if desired, by the exhaust gases, can be used in many industrial operations. There is also a possibility for the commercial development of a heat and power unit based on a Diesel-type engine which will combine an efficient and compact small-sized generating unit with a boiler heated by exhaust gases to furnish small amounts of process steam.

Water Heating

Although most process-heat requirements are too specialized to permit a general analysis, the problem of water heating is one of great importance, and offers an interesting field for improvement of the heat-power balance. The old idea that water heating with live steam is 100 per cent efficient because all the heat units in the steam appear in the hot water is, in view of the concept of byproduct power, entirely obsolete. In the near future the condensing bleeder turbine will become the standard equipment for water heating.

The simplest method of heating water, which we shall refer to as "one-stage heating," involves the operation of a condensing engine or turbine at a suitable vacuum so that the condenser cooling water is discharged at the temperature required by the process. The idea that it is economical to operate a condensing engine at 28 or 29 in. vacuum using large amounts of cooling water and then using either atmospheric pressure or live steam for water heating is one which cannot be tolerated in the modern industrial plant. Any heat discharge from the plant in condenser water is to be regarded as a serious loss. If all the water that can be heated by the steam from the engine can be used, the heat and power loads will be balanced, even though the engine is running on a condensing cycle.

Two-Stage Heating

A more efficient arrangement for heating water has been designated as two-stage heating. In this arrangement the condenser is run at a somewhat higher vacuum and steam is bled at a pressure corresponding approximately to the final temperature required in the water. A comparison of the power theoretically developed in one-stage and two-stage water heating is given in Fig. 3. It will be noted that as the final water temperature increases, a point is reached at which the power generated per 1,000 lb. of water heated is a maximum. If temperatures beyond this point are required, it is more economical to use live steam or an additional stage of bled steam for heating.

Events and Men in Power's Field

THE EDITORS WILL WELCOME THE CO-OPERATION OF READERS IN REPORTING INTERESTING HAPPENINGS, PERSONAL OR OTHERWISE

Heating and Ventilating Engineers Hold Annual Meeting at Chicago

Effect of Inclosures on Radiator Performance, Use of Sub-Atmospheric Steam for Heating, and Thermal Resistance of Air Spaces are among the many subjects discussed

OVER 500 heating and ventilating experts assembled at the Edgewater Beach Hotel, Chicago, to attend the 35th Annual Meeting of the American Society of Heating and Ventilating Engineers. During the sessions, which were held both morning and afternoon of Jan. 28, 29, 30 and 31, fifteen papers were presented and the reports of several committees discussed.

The meeting was opened by Prof. A. C. Willard, president of the society, and by O. J. Prentice, Chicago Association of Commerce, who welcomed the visiting members in behalf of the association and the City of Chicago.

Thornton Lewis, Philadelphia, Pa., was elected president for the coming year; L. A. Harding, Buffalo, N. Y., vice-president; W. H. Carrier, Newark, N. J., second vice-president and W. E. Gillham of Kansas City, Mo., treasurer. E. B. Langenberg, G. L. Larson, E. C. McIntosh and W. A. Rowe were elected members of the council, and O. P. Hood and S. A. Jillet were made honorary members. The society also adopted a rating code and a revised test code for heating boilers.

It was announced that the annual meeting for 1930 would be held in Philadelphia, Jan. 27 to 31, in conjunction with the first International Heating and Ventilating Exposition to be held at the Commercial Museum there.

Monday evening there was an informal reception and dance, and the annual banquet was held Wednesday evening. David Kenley, president of the University of Illinois, was the main speaker of the evening. The ladies were entertained on several occasions.

The first paper, presented by C. A. Thinn, chief engineer of the C. A. Dunham Co., directed attention to the control possibilities of a heating system designed to operate on pressures varying from atmospheric to 2 or 3 lb. absolute. With such a variation in pressure the temperature of the radiators ranges from 212 to 130 deg., which results in a large variation of heat emissions from each radiator. By varying the heat output of the system it is claimed that more uniform room temperatures may be maintained.

The equipment necessary for such a system is a steam source with reducing valve, a regulating plate in the inlet, and a thermostatic trap on the outlet of each radiator, a vacuum pump and an automatic pump-starting switch controlled by the pressure difference between supply and return piping. Operating data given for two different buildings showed the average steam consumption for the year, when operating with low-pressure steam, to be 33 per cent less than when the same system was operated on the ordinary vacuum principle.

The trend of the discussion indicated the general feeling that insufficient data had been given in the paper to support the claim of decreased steam consumptions.

In reply to a question regarding the ability to keep the system tight, Mr. Thinn stated that in one of the buildings tested a vacuum of 20 in. had been obtained with the piping cold, and when the pump was shut down the vacuum dropped 10 in. in three hours. The following year the same test was made and the system was found even tighter.

At the Tuesday morning session a paper by A. C. Willard, A. P. Kratz, M. K. Fahnestock and S. Konzo was presented, which reported the results of investigations made at the Engineering Experiments Stations of the University of Illinois on the effect of commercial radiator inclosures on the performance of direct cast-iron radiators placed in a room subjected to zero weather conditions. The tests were made so that the actual heating effect of the radiators as well as the steam condensing capacity could be determined for each inclosure or shield arrangement investigated.

In making the comparison an inclosure was considered better than a bare radiator under the following conditions: if a breathing-level temperature within one degree above or below 69.4 deg. was maintained; if the temperature at the ceiling was lowered; if the floor temperature was maintained constant or raised; if the main temperature in the living zone was raised; and if the steam condensation was the same or less than that of the bare radiator. One of the inclosures tested increased the mean temperature of the living zone, decreased the ceiling temperature, condensed 13 per cent less steam than the bare radiator and maintained a temperature of 69.5 deg. at the breathing line. The performance of other types of inclosures were not as satisfactory, for although the steam consumption was less, the room temperatures in the living zone decreased sufficiently to cause discomfort. A comparison of structural differences showed that the inclosure with the largest area of free opening gave the most satisfactory results.

Dr. Brabbee discussed this paper and presented some interesting results of comparisons made between flat and tubular radiators. He first presented the results of laboratory tests and then data indicating their performance when tested under actual operating conditions in rooms of entirely different shape than the test room. These tests showed a somewhat greater difference between the radiators, but in the same direction as the laboratory results.

Other discussions suggested that tests be made on other radiator types. E. H. Lockwood expressed the belief that the same steam-condensing capacities would be shown by the present standard test methods as by the methods used by Professor Willard. Professor Kratz explained that this had been found to be the case but that the old method of testing did not give data concerning the room heating effect. C. H. Fessenden, Ann

Men In the News

ANDREW W. ROBERTSON

president of the Philadelphia Company, was unanimously elected chairman of the board of directors of the Westinghouse Electric & Manufacturing Company, at a recent meeting of that board. Mr. Robertson, after practicing law in Pittsburgh became general attorney for the Philadelphia Company and later its president.

Arbor, Mich., presented results of tests made to determine the effect of surface paints on the performance of a radiator of modern design. The results appear to check fairly well with similar data reported two years ago. Compared with bare radiators, an aluminum-painted unit has a heat emission of 93.7, cream colored, 104 and glossy white, 102.

The paper, "Thermal Resistance of Air Spaces," by F. B. Rowley and A. B. Algren, presented at the Tuesday afternoon session, gave the results of co-operative research between the University of Minnesota and the A.S.H.&V.E. The several factors that affect air space coefficients are mean temperature between surfaces, width of air space, condition of surfaces and the ratio of area to thickness of space. In these experiments the air space was contained between various types of insulating board, all of which were found to give the same air space coefficients. Determinations of air-space conductance were made for spaces 0.05 in. to 1.5 in. thick and for mean temperatures of 20 to 150 deg. It was found that as the thickness of the air space increases, its conductance approaches a constant value, while there is no definite point at which the minimum conductance is reached. Apparently there is no gain in spaces more than 0.7 to 0.8 in. thick. For an air space 0.713 in. thick the conductance varies from 1.04 at 20 deg. mean temperature to 1.592 at 150 deg.

Heat transfer coefficients for various types of wall construction were presented in a paper by F. C. Houghton, Carl Gutherlet and C. G. F. Zobel. The coefficients were measured under natural weather conditions by the Nicholls heat-flow meter. All measurements were made on actual constructions.

Additional data on air infiltration were presented in a paper by G. L. Larson, C. Braatz and D. W. Nelson. The results of their experiments at the University of Wisconsin show that the air leakage through a 13-in. brick wall is greatly affected by the kind of brick, mortar and workmanship as well as the wind velocity. With a wind velocity of 20 mi. per hr. the infiltration varied from 4.59 to 16.28 cu.ft. per hr. per sq.ft. of wall for the different tests.

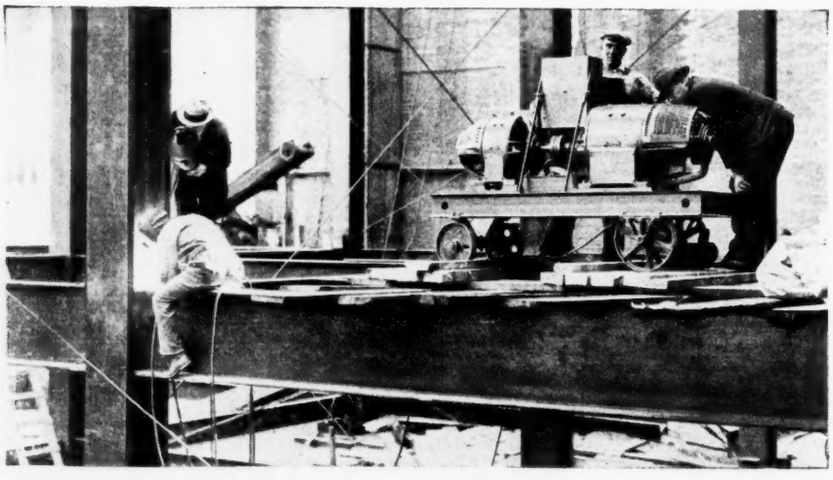
The many opportunities for cooling and humidifying buildings, especially office buildings, were pointed out in a paper presented by S. C. Bloom, Chicago, Ill. He suggested reducing to a minimum the amount of outdoor air supplied to the building and an increase in the velocity generally used in the duct system. He warned against maintaining too great a temperature difference between inside and outside air, suggesting an effective temperature midway between the outside effective temperature and 66 deg.

A humidity chart for determining relative humidities as low as 1 per cent and covering dry-bulb temperatures from 20 to 120 deg. was presented by M. C. W. Tomlinson. The chart is of the well-known Carrier type.

H. C. Russel, Chattanooga, Tenn., presented a paper which contained information and data required in the selection and operation of laundry, kitchen and hospital equipment. The results of a study of the principal factors that influence the formation of frost and condensation on windows were presented in a paper by L. W. Leonhard and J. A. Grant. The two chief factors are the dew-point temperature of the inside air and the surface temperature of the glass.

To prevent condensation this temperature must be above the dew point of the air in the room. Various suggestions, such as double glazing, circulating warm air along the surface of the window, and reducing the dew point by ventilation, were given in the paper, none of which was claimed to completely prevent condensation or frost.

Because of the frequent troubles with condensation on the windows of turbine and engine rooms this paper was of special interest to power engineers.



WHIZZING *red-hot rivets and the deafening clatter of the pneumatic hammer played no part in the construction of the new power plant for the Chalfonte-Haddon Hall Hotel at Atlantic City, N. J. Instead, this General Electric portable arc-welding machine did the job, while hotel guests rested in peace. The man watching the welder work is Atlantic City's mayor*

Fairbanks, Morse Organizes Water Supply Company

A new company known as the Fairbanks, Morse Water Supply Company has just been formed by the Chicago firm of the same name, for the purpose of supplying water to cities and industrial concerns at a definite cost per unit volume over a period of years. The company will undertake the solution of water supply problems which have heretofore confronted individual industrial concerns and cities.

After a thorough geological survey and hydraulic investigation of a plant's water supply has shown favorable possibilities, the Fairbanks, Morse Water Supply Company agrees to deliver a definite quantity and quality of water at a definite price per thousand gallons. The plan is worked out so that the industrial organization is not required to invest any money in the pumping plant. Water is purchased at a fixed price for a period of years, at the end of which time complete title to the plant passes to the industrial organization. At any time during the period the purchaser has the option of taking over the plant. In many cases the fixed price for water is so much less than the cost of city water or so much less than a plant's former pumping costs, that the new plant can be paid for out of accrued savings.

Several installations of this character are now being developed, among them a three million gallon per day plant for the City of Havre, Montana, and three plants for the City of Brooklyn, N. Y., which will be used for furnishing water for sluicing ashes at incinerator plants. At Muskegon Heights, Mich., another guaranteed supply is being developed. A number of industrial organizations have also taken advantage of this new method of water supply development.

Boiler Manufacturers Meet Feb. 5

The American Boiler Manufacturers Association will hold its annual mid-winter meeting on Feb. 5 at the Cleveland Hotel, Cleveland, Ohio, and will draw members from all parts of the country. The meeting will last only one day, during which considerable association business will be transacted.

The morning session will be devoted to group meetings in various committee rooms of the hotel, and reports will be received from the Horizontal Return-Tubular, Water-Tube, Heating, Vertical, and Oil Country divisions. After luncheon there will be a general meeting, some of the features of which will be the presidential address and reports by the committee on power shows, by representatives of the National Boiler and Pressure Vessel Inspectors, the Uniform Boiler Laws Society and by the Rivet Standardization committee. General business matters will complete the program.

*Spot * News*

PRETZELS, *to the number of 120,000 a day, can be turned out by a plant in Harrisburg, Pa., which uses gas instead of coal for oven heating. Under the older method of coal firing only 60,000 a day could be manufactured.*

* * *

AUSTRALIANS *have succeeded in burning brown coal containing as high as 64 per cent moisture and having a heating value as low as 4,000 B.t.u. per pound.*

* * *

ONE MILLION HORSEPOWER *is again the goal of a hydro-electric project, now under preliminary investigation in British Columbia, on the Chilco River. It is proposed to divert the entire river through the coast mountains to the sea, thus creating a series of potential power sources not at present available.*

* * *

SEVEN SISTERS FALLS, *on the Winnipeg River, is to yield 112,000 hp. by the year 1930, when a development lately started by the Northwestern Power Company is completed. The ultimate capacity of the plant will be 225,000 horsepower.*

* * *

F. W. PEEK, JR., *lightning engineer of the General Electric Company, announced at the annual meeting of the A.I.E.E. that he is slowly creeping up on nature. He can now produce a laboratory lightning bolt of 5 million volts, whereas 3½ million was his limit a year ago. The "miniature" discharge is sixteen feet long.*

* * *

INTERESTS *identified with the Duke Power Company, of Charlotte, N. C., have purchased all land below the 420-ft. contour at the Calhoun Falls site on the Savannah River. A $14,000,000 industrial development is to be promoted in connection with the power site.*

* * *

SEVEN MILLION DOLLARS *will be spent by the Georgia Power Company in 1929, states its president, P. S. Arkwright. Most of the money will be used for the extension of existing plants and distribution lines, as well as for street railway and other public-utility uses.*

German Marine Court Renders Decision on the Motorship "Kungsholm" Explosion

FIVE men were burned to death and nineteen others were severely injured, following a crankcase explosion on board the motorship "Kungsholm," immediately after the vessel had completed her trial trip in the North Sea, on Oct. 14, 1928. The German Marine Court, which subsequently sat on the case, has recently rendered its decision, holding that no one was directly responsible for the accident. The following facts concerning the disaster were established by the court:

The ship is equipped with two double-acting, four-stroke-cycle, six-cylinder Burmeister & Wain Diesel engines. The explosion started in the crankcase of the starboard engine, but did not disable it, as both engines continued to run for six minutes following the explosion. The return trip to Cuxhaven was completed with the port engine.

The investigation showed that a hot bearing developed in an idler bushing of the valve gear chain drive. The bronze bushing locked itself solidly to the shaft, causing the pins which held it in place to shear, so that it rotated with the shaft on the bearing surface. The heat developed by the resulting friction vaporized the lubricating oil. The first explosion occurred only after a flame had propagated itself from within the valve housings into the crankcase in which the vaporized oil and air formed an explosive mixture. All witnesses testified that this explosion was not particularly severe. The result was, however, disastrous, as it blew out two access doors from the crankcase, which allowed the vaporized oil to escape and to ignite into a thin but intense flame.

This flame was diverted by striking a steel bulkhead and instantly propagated itself in an upward winding path through the entire engine room, finally exploding with a severe detonation under the skylight, which was hurled from its fastenings. No damage was done by the explosion in the engine room. The medical examination showed that the unfortunate fatalities and the injuries to the survivors were due entirely to severe burns.

The question arose as to whether the explosion in the engine room had been caused or intensified by the presence of benzine vapor. It was shown that benzine had been used for cleaning the fuel-oil strainers before the trial trip was started, but that no benzine was stored in the engine room.

The examining experts differed in their opinions, some assuming that benzine vapors had caused the second explosion, while others traced the origin of the fatal thin flame to the ignition of lubricating oil vapor which was forced out into the engine room by the first and less severe explosion.

The verdict of the court held no one responsible for the accident, stating that no proof of negligence had been shown, and that there was no definite evidence of the explosion having been caused or intensified by the presence of benzine vapors.

Modern 450-lb. Boiler Plant for Anheuser-Busch, Inc.

Work has been started on the erection of the boiler plant section of a new power plant for Anheuser-Busch, Inc., St. Louis, Mo. Briefly, the plant is to consist of three 10,760-sq.ft. Springfield boilers, designed for 506 lb. pressure and to be operated at 450 lb. gage. The boilers will be equipped with water walls, Elesco superheaters and Diamond soot blowers.

Each boiler will be served by two pulverized fuel burners, the fuel to each burner to be supplied by a unit ball pulverizer made by the Hardinge Co. Each boiler is to be further equipped with a Thermix plate-type air preheater and a Thermix dust collector furnished by the Pratt-Daniel Company.

Treated water will be furnished for the boilers from a Cochrane lime-soda hot-process softener, and there will be further treatment with tri-sodium phosphate. The water will be fed to the boilers by Dean-Hill, five-stage centrifugal pumps, consisting of a two-stage low-pressure element and a three-stage high-pressure element, both mounted on one bed plate and driven by a back-pressure turbine.

The plant is being installed in the present boiler house. The first section of the work will consist of the erection of two boilers. After these have been placed in service, possibly in July, the remaining old boilers will be dismantled, making room for the third boiler and a new turbine-generator room.

Canadian Engineers to Hold Annual Meeting

The forty-third annual general meeting of the Engineering Institute of Canada will be held at Hamilton, Ontario, Feb. 13-15, at the Royal Connaught Hotel. The first day of the meeting will be devoted to registration and to the transaction of general society business. The Institute will install its new president on the afternoon of that day.

The technical sessions will begin Thursday, Feb. 14, and will contain much of interest to power men. Among the papers to be presented will be "The Importance of Geology to Engineering Work," by Dr. H. Ries, of Cornell University, and "The St. Lawrence Problem—Some Canadian Economic Aspects," by Leslie R. Thomson, con-

sulting engineer. These papers will be given on Thursday. The following day an electrical session will include "Design of Generators for Paugan Falls Power Plant," by J. R. Dunbar and H. A. Ricker, "220-Kv. Transformers at Leaside," by D. W. Callander, and "Protective Relay Installation at the Toronto-Leaside Station of the Hydro-Electric Power Commission," by E. M. Wood. An afternoon session on Feb. 15 will include a paper entitled "The Influence of Various Factors on the Power and Economy of a Gasoline Engine," by Prof. E. A. Allcut, of the University of Toronto.

Personals

M. A. Gordy has been appointed Southeastern district manager for the United States Electric Tool Company, of Cincinnati, Ohio. Mr. Gordy's office will be at the Norris Building, Atlanta, Ga.

G. M. Gadsby has resigned as president of the West Penn Power Company, Pittsburgh, Pa., and will become associated with the Electric Bond & Share Company, of New York City.

R. C. Gilbert has been appointed manager of the Detroit, Mich., office of the Consolidation Coal Company, New York City, with headquarters in the Barlum Tower Building, Detroit.

Frank H. Sprague has resigned as sales manager of the Skidmore Corporation, and is now associated with George B. Burke, vice-president, Sarco Company, Inc., Chicago, Ill. Mr. Sprague will act as sales manager of the Sarco Company's newly created Western Heating Division with headquarters at its new offices in the Engineering Building.

R. J. Scanlan, formerly Chief of the Materials Inspection and Testing Department of Thomas E. Murray, Inc., New York City, has joined the general sales department of the Walworth Company as sales engineer, with headquarters in New York.

Moses H. Teaze and James W. Tower have been admitted as partners into the firm of Hardy S. Ferguson and Company, consulting engineers, 200 Fifth Ave., New York City. The firm will continue its specialization in industrial and power-plant design work.

B. W. Aspelin, formerly purchasing agent at the Bristol, Conn., plant of the Veeder-Root Corporation, has accepted a position as purchasing agent for the Hartford Machine Screw Company.

A. G. Olson has been appointed manager of the Cleveland, Ohio, office of The Consolidation Coal Company, New York City, with headquarters in the Union Trust Building.

Coming Conventions

American Boiler Manufacturers Association, mid winter meeting, Cleveland, Ohio, Feb. 5, 1929. A. C. Baker, secretary, 801 Rockefeller Bldg., Cleveland, Ohio.

American Institute of Refrigeration, at Washington, May, 1929. Louis Laron, secretary, 203 West 13th St., New York City.

American Oil Burner Association, annual convention, Hotel Pennsylvania New York City, April 9-11, 1929. For information, address the headquarters of the Association at 420 Madison Ave., New York City.

American Society of Mechanical Engineers, spring meeting, Salt Lake City, Utah, July 1-4, 1929. Spring meeting, Rochester, N. Y., week of May 13. Calvin Rice, secretary, 29 West 39th St., New York City.

Association of Iron and Steel Electrical Engineers, 25th annual convention, Pittsburgh, Pa., June 17-22, 1929. A. A. Stewart, secretary, Pittsburgh Steel Co., Monessen, Pa.

Canadian Electrical Association, annual convention, to be held June 19-21, at St. Andrew-by-the-Sea, N. B. H. M. Lyster, secretary, Power Building, Montreal, Que.

Engineering Institute of Canada, annual general and professional meeting, at Hamilton, Ont., Feb. 13-15, 1929. R. J. Durley, secretary, 2050 Mansfield St., Montreal, Que.

Master Boiler Makers Association, at Atlanta, Ga., May 21-24. H. D. Vought, secretary, 26 Cortlandt St., New York City.

Midwest Power Conference and Exhibition, at Chicago, Feb. 12-16; Conference headquarters at the Palmer House, Exhibition at the Coliseum; G. E. Pfisterer, secretary, 53 West Jackson Blvd., Chicago.

National Marine Engineers Beneficial Association. The 54th annual meeting will be held in Washington, D. C., Feb. 11-16, at the Hotel Hamilton.

World Engineering Conference, Tokyo, Japan, October, 1929. All correspondence should be addressed to the Secretary, World Engineering Conference, Nikon Kogyo Club, Morunouchi, Tokyo.

Business Notes

The Cothran-Bayles Company has been formed in Charlotte, N. C., to conduct a sales engineering business in the power-plant field. The address of the company will be 909 Commercial Bank Building, that city.

The Lincoln Electric Company, Cleveland, Ohio, announces the recent appointment of J. E. Durstine as district sales representative for the Southeast, with headquarters at Birmingham, Ala., and of H. P. Egan as district sales representative for central Ohio with headquarters at Columbus.

Bradshaw & Company has recently been organized to represent manufacturers of power-plant and steel-mill equipment in the Pittsburgh District. Grant D. Bradshaw, formerly president of Andrews-Bradshaw Company from its organization in 1915 until its recent consolidation with Blaw-Knox Company, will be president of the new company.

Veeder-Root, Inc., Hartford, Conn., has consolidated its purchasing under J. M. Brown, purchasing agent at the Hartford plant.

The Allis-Chalmers Manufacturing Company, Milwaukee, Wis., announces that it will enlarge its stock of Texrope drives up to 50 hp., to include all the popular motor speeds and ratings, with a large choice of driven speeds in a range of ratios from 1:1 up to 7:1.

The Chicago Pump Company has recently made additions and changes in its representation in several cities, as follows: Ace Combustion & Engineering Company, 222 Milan St., Shreveport, La.; Harry Cooper Supply Company,

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	Market Quoting	Price per Ton
Navy Standard	New York	$2.35@$2.40
Kanawha	Columbus	$1.25@1.45
Smokeless	Cincinnati	2.25
Smokeless	Chicago	2.25
S. E. Kentucky	Chicago	1.35@ 1.60
Steam	Pittsburgh	1.60@ 1.70
Gas Slack	Pittsburgh	.75@ .90
Big Seam	Birmingham	1.25@ 1.50
Anthracite (Gross Tons)		
Buckwheat	New York	$2.75@$3.25
Barley	New York	1.00@ 1.75

FUEL OIL

New York—Jan. 31, f.o.b. Bayonne, N. J., 28@34 deg., Baumé, industrial use, tank-car lots, 4⅜c. per gal.; 36@40 deg., furnace, tank-car lots, 6½c. per gal.

St. Louis — Jan. 22, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.40 per bbl. or 42 gal.; 26@28 deg., $1.45 per bbl.; 28@30 deg., $1.50 per bbl.; 30@32 deg., $1.55 per bbl.; 32@36 deg., gas oil, 4.7c. per gal.; 38@40 deg., distillate, 5.75c.

Pittsburgh—Jan. 22, f.o.b. local refinery, 30@34 deg., fuel oil 5c. per gal.; 36@40 deg., 5¼c. per gal.

Philadelphia—Jan. 22, 13@19 deg., $0.95@$1.02 per bbl. or 42 gal.; 22 deg. plus, $1.47@$1.53 per bbl.; 26@30 deg., $2.00@$2.06 per bbl.

Cincinnati — Jan. 28, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5c. per gal.; 26@30 deg., 5½c. per gal.; 30@32 deg., 5.95c. per gal.

Chicago—Jan. 22, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl. or 42 gal.; 22@26 deg., 65c. per bbl.; 26@30 deg., 72½c. per bbl.; 30@32 deg., 97½c.@$1 per bbl.

Boston—Jan. 28, tank-car lots, f.o.b. 12@14 deg. Baumé, 4.5c. per gal.; 28@32 deg., 5.65c. per gal.

Dallas—Jan. 26, f.o.b. local refinery, 26@30 deg., $1.20 per bbl. or 42 gallons.

1224 Chemical Bldg., St. Louis, Mo.; F. L. Bunker, P. O. Box 1223, Greensboro, N. C.; L. Brandenberger, 149 W. 2nd St., South, Salt Lake City, Utah; Alfred P. Brown, Dexter Horton Bldg., Seattle, Wash.; John A. Butler, 18 Catherine St., Lynbrook, L. I.; Robert B. Brown, Newark, N. J.; J. J. Smith, 3620 Ednor Road, Baltimore, Md.

Trade Catalogs

Arc Welder—An automatic arc welder for railroad ties is illustrated and described in Bulletin GEA-1022A, issued by the General Electric Company, Schenectady, N. Y. This bulletin describes the new metal railroad tie fabricated from old rails and shows how the scrap material is made up into ties.

Electrical Testing—The Wagner Electric Corporation, St. Louis, Mo., has published Bulletin No. 138, under the name of "Manual of Electrical Testing." All the commonly used methods of making resistance measurements and determining power input to motors, magnetization curves, temperatures and insulation resistance are included. The bulletin contains 20 pages.

Blowers—A leaflet, Bulletin No. 121, has been issued by the Connersville Blower Company, Connersville, Ind., which pictures a number of this company's blowers for direct and belt drive. A small amount of text and several tables are included.

Water-Tube Boilers—The Springfield Boiler Company, Springfield, Ill., has issued catalog No. 28, describing its line of all-steel water-tube boilers. The publication is largely illustrative, showing photographs of parts and installations, as well as reproductions of blueprint drawings of the equipment.

Insulation-Testing Instruments—Catalog 1205, issued recently by James G. Biddle, Philadelphia, Pa., gives in 48 pages a complete description of the "Megger" insulation-testing equipment. The catalog contains many cuts, tables and descriptive paragraphs.

With the Society Sections

A. S. M. E., Knoxville Regional Meeting, Mar. 21-23, 1929. Technical program and trips to points of interest.

American Water Works Association, Montana Section. Annual convention, to be held April 4 and 5 at Great Falls, Mont.

American Water Works Association, Rocky Mountain Section. Annual meeting, to be held Feb. 14 and 15, at Denver, Colo.

Engineers' Club of St. Louis. Meeting Feb. 13, 1929. Subject: "Steam Storage and Steam Distribution," by R. A. Longworthy, vice-president and general manager of Ruthes Accumulator Company.

Indiana Engineering Society and Indianapolis Section, A. S. M. E. Joint meeting, Feb. 7 and 8, at Hotel Severin, Indianapolis, Ind. Several papers on steam and hydro-electric plants, sanitation, and welding will be given.

Louisiana Engineering Society. Monthly meeting, Feb. 25, at New Orleans. Subject: "Electric Welding of Steel Buildings," by F. P. McKibben.

New Plant Construction

COMPILED BY THE MCGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

California—Water Resources Committee of State Legislature have recommended the immediate construction of Kennett dam on the upper Sacramento River, approximately $70,000,000; also Salt Water Barrier Dam on Carquinez straits at Army point to prevent entrance of sea water into Sacramento and San Joaquin rivers delta, $50,000,000, and system of dams, aqueducts, pumping plants, etc., to transfer surplus water from the Sacramento river to San Joaquin river during periods of drought in San Joaquin Valley. $24,000,000.

Calif., San Francisco — Dept. of Public Works, plans terminal facilities to include refrigeration plant, dried fruit terminal, etc. for State Harbor Commission. Estimated cost $2,439,000.

Colorado—Marion Mining Co., Alamosa, has been granted permit for the construction of two hydro-electric power plants and dams on the Alamosa river in Conejos and Rio Grande counties, one 175 hp. and one 240 hp., also transmission lines, etc.

Colo., Lamar—City Council, c/o J. H. Myers, is having plans prepared for a 2,000 kw. addition to steam generating plant. Wood & Weber, Midland Savings Bank Bldg., Denver, are consulting engineers.

Conn., New Britain — H. Doerr, 150 Shuttle Meadow Ave., is receiving bids for a 25x70 ft. cold storage plant at Spring and Hartford Sts. Estimated cost $40,000. L. J. Thompson, 586 Corbin Ave., is engineer.

Illinois—Illinois Light & Power Co., 231 South La Salle St., Chicago, has been granted permit to construct a hydro-electric plant and dam on the Kankakee River between Will and Kankakee counties.

Ind., Marion—U. S. Government will receive bids until Feb. 12 for the construction of a hospital including steam heating, ventilation and refrigeration systems, etc., here. Estimated cost $600,000. J. A. Wetmore, Washington, D. C., is architect.

Ia., Des Moines — Iowa Power & Light Co., C. A. Leland, Jr., V. Pres. and Gen. Mgr., 802 Locust St., plans to expend $375,000 for extensions and improvements to plant. Plans include new sub-stations at Valley Junction and South Des Moines, also 44,000 v. transmission lines, etc.

La., New Orleans—S. Stone Jr. & Co., Masonic Temple Bldg., Engrs., will soon award contract for the construction of an ice plant on Carrollton St. Estimated cost $45,000. Owner not announced.

La., Tallulah—City will receive bids until Feb. 26, for the construction of a sewerage system including two pump pits and superstructures, two electrically operated sewage pumping lifts, etc. H. A. Mentz & Co., Hammond, are engineers.

Md., Baltimore—W. E. Harris, c/o F. N. Iglehart & Co., 11 East Lexington St., awarded contract for the construction of an 8 story apartment building at Mt. Vernon and Cathedral Sts. to Consolidated Engineering Co., 20 East Franklin St. Estimated cost $500,000. Steam heating system, etc. will be installed.

Md., Baltimore — St. Mary's Seminary, Paca and McCulloh Sts., awarded contract for the construction of a 70 x 130 ft. boiler house at Belvidere and Roland Ave., to H. T. Booth, 1010 Denrike Bldg., Washington, D. C.

Md., College Park—University of Maryland, plans the construction of a central heating plant. Estimated cost $200,000. Engineer not selected.

Mass., Boston — Architect's Building Trust, J. Walker, and R. W. Peabody, 31 West St., is having plans prepared for the construction of a 25 story office building at 120 Boylston St. Estimated cost $4,000,000. Blackall, Clapp & Whittemore, 31 West St., are architects.

Mass., Boston—Edison Electric Illuminating Co., 39 Boylston St., awarded contract for the construction of a transformer building at Allston District to W. M. Bailey Co., 88 Broad St.

Mass., Boston — Metropolitan District Commission, 1 Ashburton Pl., plans the construction of a 6 story office building. Estimated cost $1,000,000. Architect not selected.

Mich., Detroit—Dept. of Water Supply, plans the construction of a waterworks system including high lift pumping station, boiler house, generating plant, switch house, etc. G. H. Fenkell, 735 Randolph St., is engineer.

Mich., Detroit—Detroit Edison Co., 2000 Second Blvd., awarded contract for the construction of a sub-station on Second Blvd., to A. A. Albrecht Co., Penobscot Bldg. Estimated cost $150,000.

Mich., Detroit—Detroit Union Produce Terminal Co., 7004 West Fort St., c/o Green Real Estate Co., awarded contract for a produce terminal including loading docks, etc., on West Fort St. to Dwight P. Robinson, 125 East 46th St., New York, N. Y. Estimated cost $5,000,000.

Miss., Pascagoula—City will soon award contract for waterworks improvements, including wells, pumps, etc.

Mo., St. Louis—Alco Investment Co., c/o V. A. Chinberg, 808 Chestnut St., will build a 17 story apartment building, including steam heating system, etc., at Lindell and Euclid Sts. Estimated cost $2,000,000. Nolte & Nauman, 614 Fullerton Bldg., are architects. Work will be done by separate contracts.

Mo., St. Louis—Fourmen Realty Co., S. Goldstein, Pres., c/o L. F. Abrams, 1123 Chemical Bldg., Archt., awarded contract for an 8 story hotel and department store at Easton St. and Hamilton Ave. to S. Abrahams Construction Co., 1123 Chemical Bldg. Estimated cost $1,000,000. Steam heating system, etc. will be installed.

Mo., Webster Groves — Preparatory Diocesan Seminary, c/o J. J. Glennon, 4401 Lindell Blvd., St. Louis, will soon receive bids for the construction of a seminary, including steam heating system, etc., at South Laclede Station and East Jackson Rds. Estimated cost $1,400,000. H. P. Hess, Ambassador Bldg., St. Louis, is architect.

N. J., Atlantic City—L. G. Brooks, 65 Madison Ave., New York, N. Y., Archt., will receive bids about April 1 for the construction of an 18 story hotel, including steam heating and ventilation systems, boilers, elevators, etc., at Boardwalk and Boston Ave., for Hotel Mayfair, c/o M. Ellis, 419 Arch St., Philadelphia, Pa. Estimated cost $1,500,000. T. Golding, 597 5th Ave., New York, N. Y., is engineer.

N. J., Elizabeth—Krumar & Burnstein, c/o W. Clifford, Jr., 293 Morris Ave., Archt. will receive bids about Feb. 15 for the construction of an ice plant at South 7th St.

and Elizabeth River. Estimated cost $50,000.

N. J., Long Branch—Long Branch Power & Light Co. awarded contract for the construction of a power plant, to E. Schoenthaler, 252 Long Branch Ave. Estimated cost $50,000.

N. J., Long Branch—W. H. Pawson, 25 West 43rd St., is having plans prepared for a 7 story hotel, etc. including steam heating and ventilation systems, boilers, elevators, etc. on Ocean Ave. Estimated cost $3,000,000. Ellis, Aaronson & Heidrich, 25 West 43rd St., New York, N. Y., are architects.

N. J., Montville—Jersey Central Power & Light Co., 20 South St., Morristown, plans the construction of a gas generating station here. Estimated cost $40,000. Engineer not selected.

N. J., Newark — Corp., c/o National Newark & Essex Banking Co., 752 Broad St., plans the construction of a 30 story office building at Broad St. between Clinton and Commerce Sts. Estimated cost $10,000,000. Architect not announced.

N. J., Trenton—State House Commission, will receive bids until Feb. 18, for the construction of a central power plant at State office building, East State St. H. Kelly, 219 East Hanover St., is engineer.

N. Y., Brooklyn—Dept. of Welfare, New York, received lowest bids for the construction of a generating plant from G. E. Gibson Co., 441 Lexington Ave., New York, also refrigeration and ice-making plant from Carbondale New York Co. Inc., 173 Christopher St., New York. Estimated cost $36,000 and $50,000 respectively.

N. Y., Oswego — City plans an election Feb. 7 to vote $100,000 bonds for electrification of water pumps, mains, etc. Hagen & Whipple, are engineers.

N. Y., Rochester — Phillips & Scranton, 311 Alexander St., Archts., will receive bids in February for the construction of an 8 story hotel including steam heating, ventilation and refrigeration systems, etc., boilers, elevators, etc., on Cumberland St., for J. Joroslow, 176 Meigs St. Estimated cost $1,000,000.

O., Akron—Akronia Hotel Co., awarded contract for a 21 story hotel at North Main and Federal Sts., to J. W. Kopman, 530 North Union St., St. Louis, Mo. Estimated cost $1,675,000.

O., Cincinnati—Hamilton County, plans the construction of a sewage system including pumping station, etc. Estimated cost $47,463. L. C. Boyatt, Court House, is engineer.

O., Cleveland — Cleveland Electric Illuminating Co., W. H. Hartman, Purch. Agt. Illuminating Bldg., is receiving bids for the construction of an electric sub-station on Canal Rd. Estimated cost $150,000. Private plans.

O., Cleveland—Cleveland Union Terminal Co., C. J. Herbold, Supt. of Constr., Terminal Tower, will soon award contract for the construction of six cable terminal houses, six circuit breaker houses and two motor generator houses. Estimated cost $250,000. Private plans.

O., Cleveland—Pearl Street Savings & Loan Co., A. F. Humel, Pres., West 25th St. and Clark Ave., awarded contract for a 4 story bank and office building to H. E. Klefman Co., 2844 Lorain Ave. Estimated cost $750,000. Steam heating system, etc. will be installed.

O., Cleveland — Shaker Co., c/o J. J. Arnold, V. Pres., Terminal Tower, awarded contract for a 7 story, apartment building at Moreland Circle to Aronberg-Fried Co., Terminal Tower. Estimated cost $750,000. Steam heating system, etc., will be installed.

O., Toledo—Toledo Ice & Fuel Co., Jefferson Ave., awarded contract for the construction of an ice plant to C. Coneby, 1556 Ansel Rd. Estimated cost $200,000.

Pa., Erie—Erie Dry Goods Co. awarded contract for a 6 story department store to Sessinghaus & Ostergaard, 1115 Peach St. Estimated cost $1,000,000. Steam heating and ventilation systems, elevators, etc., will be installed.

Pa., Pittsburgh—Allegheny County Commissioners, Court House will receive bids until Feb. 19 for a 6 story office building at Ross and Diamond Sts. Estimated cost $1,000,000. S. Roush, 519 Smithfield St., is architect.

Pa., Pittsburgh—Sears Roebuck Co., 106 West Randolph St., Chicago, Ill., is having plans prepared for the construction of a department store on North Heland Ave. Estimated cost $3,000,000. Nimmons, Carr & Wright, 333 North Michigan Blvd., Chicago, Ill., are architects.

Tenn., Maryville—City plans an election soon to vote $200,000 bonds for the construction of an electric light plant.

Texas — Western Produce Co., W. R. White, Pres., Abilene, plans the construction of a creamery including remodeling of poultry packing and cold storage plants at Abilene, also soon takes bids for a creamery and produce house to include refrigeration plant, boilers, ice machines, etc., at Lubbock. Estimated cost $100,000 and $200,000 respectively. Privaet plans.

Tex., Brownwood—J. B. Carrington and G. L. Bruner, 615 City National Bank, San Antonio, awarded contract for the construction of a 10 story hotel here, to A. F. Marshall, Rust Bldg., San Antonio. Estimated cost $500,000. Steam heating and ventilation systems, elevators, etc., will be installed.

Tex., Dallas—City c/o E. Goforth, Secy., will receive bids until Feb. 25 for waterworks improvements including pump house, etc. D. Morey, 417 Praetorian Bldg., is consulting engineer.

Tex., Donna—Caps & Parker, will build an ice and packing plant on Third St. Work will be done by day labor.

Tex., El Paso—Adbou Poultry & Produce Co., 700 South Santa Fe St., awarded contract for the construction of a cold storage plant and warehouse, to R. E. McKee, El Paso. Estimated cost $200,000.

Tex., San Antonio—San Antonio Public Service Co., W. B. Tuttle, Pres., plans to expend $725,000 for extensions and improvements to plant to include sub-stations, transformers, etc. Private plans.

Wash., Centralia—City Commission, had preliminary plans prepared for the construction of a hydro-electric plant to develop 11,000 hp. Plans include diversion dam, power house, two 2,500 hp. generating units, etc. Estimated cost $1,000,000.

Ont., London—Hotel London, R. Lussier, is having plans prepared for an 8 story, addition to hotel including steam heating system, etc., on Wellington St. Estimated cost $500,000. J. M. Moore & Co., 489 Richmond St., are architects.

Ont., Toronto — Alcazar Apartments Ltd., 606 C. P. R. Bldg., plans the construction of a 7 story hotel and apartment building, including steam heating system, elevators, etc., at Jarvis and Gerrard Sts. Estimated cost $600,000. H. C. Roberts, 81 Victoria St., is architect.

Ont., Windsor—L. A. Merlo, c/o Merlo, Merlo & Ray, Sandwich St., Ford City, plans the construction of a 16 story, office building on Ouellete Ave. Estimated cost $1,000,000.

Brazil, Bahia — Electric Bond & Share Co., 2 Rector St., New York, N. Y., subsidiary of American Foreign Power Co. and Emprezas Electricas Brasileiras, Bahia, will install new automatic telephone system throughout the city, also construct a hydro-electric plant on the Paraguassu River, and two traffic elevators to link together two transportation systems. Work will be done by day labor.

Equipment Wanted

Air Compressors, Motors, etc.—City of San Antonio, Tex., will receive bids until Feb. 11 for four centrifugal air compressors, motors, etc., for proposed sewage disposal plant. Estimated cost $1,000,000.

Boiler—E. B. Reynolds, Supt., Salisburg, Mo., is in the market for a 150 hp. return tubular boiler, 150 lb. pressure.

Electrical Equipment—East Bay Municipal Utility Dist., J. H. Kimball, Secy., 512 16th St., Oakland, Calif., will receive bids until Feb. 6, for electrical equipment for Walnut Creek sub-station in connection with Mokelumne River project.

Engines—U. S. Engineer's Office, Rock Island, Ill., plans the installation of three marine gasoline engines in U. S. Launches, Moline, Dubuque and Acton.

Generator — U. S. Engineers Office, Detroit, Mich., will receive bids until Feb. 18, for a steam turbine generator.

Ice Machines—Bureau of Supplies & Accounts, Navy Dept., Washington, D. C., is in the market for ethyl chloride ice machines for Navy Yard, Boston, Mass.

Pumps, etc. — Winter Garden Development Co., c/o T. E. Logan, Secy., Winter Haven, Tex., is receiving bids for pumps, etc., for proposed irrigation project. Estimated cost $100,000.

Refrigeration Unit, Switchboard, etc. — A. L. Flint, General Purchasing Officer of the Panama Canal, Washington, D. C., will receive bids until Feb. 15, for an electrically operated refrigeration unit, switchboard, etc.

Industrial Projects

Ala., Bessemer—CAR MANUFACTURING PLANT—Pullman Car & Mfg. Corp., 79 East Adams St., Chicago, Ill., is receiving bids for a 200 x 1,500 ft. and 150 x 1,200 ft. car manufacturing plant here. Estimated cost $3,000,000.

Conn., Hartford — GOLD LEAF FACTORY and BOILER HOUSE—M. Swift & Son, 100 Love Lane, is receiving bids for the construction of a 2 story, 55 x 175 ft. factory including 25 x 40 ft. boiler house, etc. Mylchrest & Reynolds, 238 Palm St., are architects.

Ill., Chicago — CABLE FACTORY — Western Electric Co., 48th Ave. and West 22nd St., awarded contract for extension and reconstruction of cable factory to Turner Construction Co., 228 North La Salle St. Estmated cost $1,500,000.

Ill., Decatur—GAS PLANT ADDITION —Illinois Power & Light Co., 231 South La Salle St., Chicago, plans the construction of a 30 x 30 ft. addition to gas plant here. Estimated cost $110,000. Work will be done by owner's forces. Equipment contract awarded.

Ill., East St. Louis—RAILROAD SHOPS and BOILER HOUSE — Mobile & Ohio R.R., Fullerton Bldg., St. Louis, will soon award contract for the construction of a roundhouse, boiler house, etc., here. Estimated cost $225,000. B. A. Wood is chief engineer.

Md., Baltimore — SOAP FACTORY — Procter & Gamble Co., Gwynne Bldg., Cincinnati, O., will soon receive bids for the construction of a soap factory at Locust Point here. Estimated cost approximately $5,000,000. H. Manley, 550 East 53rd St., New York, is architect.

Md., Baltimore—CABLE FACTORY and POWER HOUSE—Western Electric Co., E. S. Bloom, Pres., 195 Broadway, New York, N. Y., subsidiary of American Telephone & Telegraph Co., awarded contract for the construction of a group of buildings for cable factory including power house, etc. to H. K. Ferguson Co., Hanna Bldg., Cleveland, O. Estimated cost $15,000,000.

Mo., St. Louis—PAPER MILL—Hinde & Dauch Paper Co., W. W. Forsman, Mgr., 5110 Penrose St., awarded contract for a 1 story, 79 x 468 ft. paper mill to O. Randolph Inc., 53 West Jackson Blvd., Chicago, Ill. Estimated cost $125,000.

N. Y., Mariners Harbor (Staten Island P. O.)—OIL REFINERY—Gulf Refining Co., 21 State St., New York, N. Y., subsidiary of Gulf Oil Corp., will build an oil refinery here. Estimated cost $45,000,000. Work will be done by separate contracts.

O., Cleveland—BOLT ond NUT FACTORY ADDITION—Lamson & Session Co., G. W. Hinds, 1971 West 85th St., awarded contract for a 4 story, 83 x 182 ft. addition to factory at West 85th St. and Franklin Ave. to Industrial Construction Co., 308 Euclid Ave. Estimated cost $200,000.

O., Cleveland — CHROME NICKEL PLANT—Sterling Brass Co., S. L. Weil, Pres., 9600 St. Catherine Ave., plans the construction of a chrome nickel plant at East 96th St. and St. Catherine Ave. Estimated cost $60,000. Architect not selected.

Pa., Ambridge—PIPE PLANT—A. M. Byers Co., Clark Bldg., Pittsburgh, is having plans prepared for the construction of a pipe plant here. Estimated cost $10,000,000. H. A. Brassert & Co., 310 South Michigan Ave., Chicago, Ill., are engineers.

Pa., Pittsburgh—CORK and LINOLEUM PRODUCTS PLANT — Armstrong Cork Co., C. D. Armstrong, Jr., Alleghaney River and 24th St., is having plans prepared for the construction of a cork and linoleum products plant. Estimated cost $1,000,000.

W. Va., Charleston — SHEET GLASS FACTORY and HEATING PLANT — Libby-Owens Sheet Glass Co., Nicholas Bldg., Toledo, O., awarded contract for extensions to factory and heating plant here, to H. B. Agsten & Sons, 417 Washington, Charleston.

W. Va., Wierton — BLAST FURNACE and BY-PRODUCT OVENS — Wierton Steel Co. is having plans prepared for the construction of a blast furnace and by-product ovens. Estimated cost $10,000,000. Private plans.

Ont., New Toronto — FABRIKOID PLANT ADDITION—Canadian Fabrikoid Co., 22nd St., plans addition to fabrikoid plant. Estimated cost $100,000. Canadian Industries Ltd., Canada Cement Bldg., Montreal, Que., is architect and engineer.